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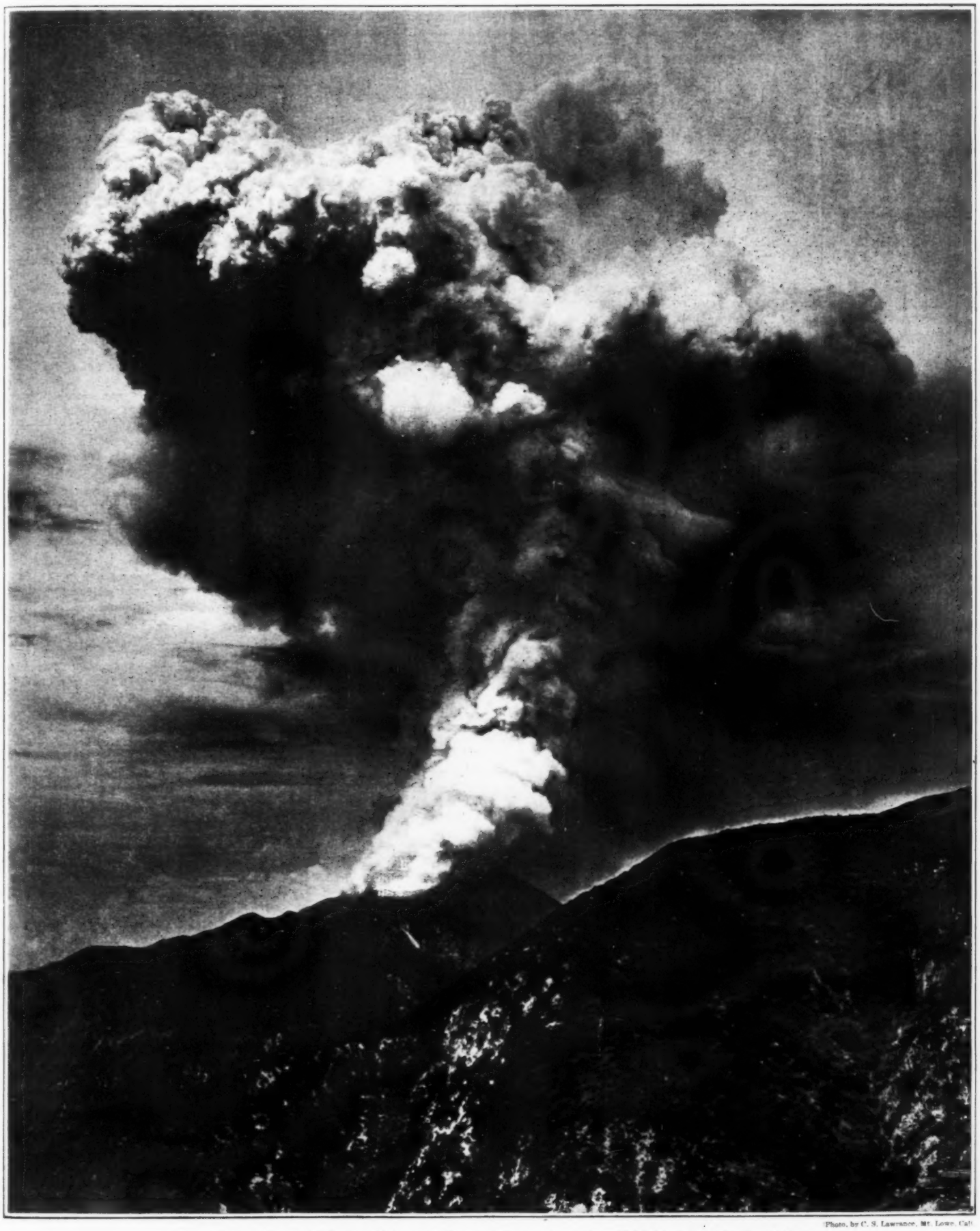

Photo. by C. S. Lawrance, Mt. Lowe, Cal.

Forest fire producing clouds over Sister Elsie Peak. View westward from Echo Mountain 10 miles distant

CLOUDS INDUCED BY FOREST FIRES (See p. 118)

Illuminating Devices in the Great War—I

An Account of Aerial Lighting Devices and Their Development from 1914 to the Armistice

By Capt. H. M. Brayton, Ord. R. C.*

ILLUMINATING devices played a very important part in the great war which has just been brought to such a splendid conclusion. For the first time in history science was made to turn night into day and thereby make it possible for the soldier to continue his fight even though the sun had ceased to give its light. In former wars the element of surprise was very effective. Illuminating devices almost did away with such surprises in the present war.

Germany, the leader in applying science for war, had long realized the need and the necessity of such things. She had carried on the most extensive researches for years in this as well as in other fields. The result was that when the first shot was fired in 1914 Germany had illuminating shell and illuminating bombs for use on the western front. The Allies had none. England had done a little experimentinng toward the development of such a shell but it was far from perfected to say nothing of being in manufacture and at the front in quantity. The situation was serious. It gave complete control of no-man's-land at night to the enemy. Secret movements of troops as in former times, were very often rendered impossible by this constant illumination from the German trenches.

At the beginning of the war when the Allied soldiers desired to see what was going on out in front of their trenches they would make noises designed to make the enemy believe that they were preparing a raid. The result was that the Germans would promptly send up an illuminating shell which gave the English or French the view desired. This method was ingenious but at times a bit uncertain.

Needless to state that the foreign governments took immediate steps to perfect the necessary shell for this special use. It took a long time and much careful experimenting to produce a shell which would function satisfactorily under practical conditions of service. Many precious months elapsed before a successful Allied illuminating projectile made its appearance at the front.

All this happened before we went into the struggle. Our Ordnance Department took no steps at that time to develop such a shell for our army. It was not until we actually entered the conflict in the spring of 1917 that the problem was really taken up in earnest by our Ordnance engineers. Even then the full difficulties to be overcome and the difficult nature of the problems involved were not realized by those put in charge of the work. Time did not permit delving into those finer problems of science which really needed to be investigated before quick results could be obtained. The cut-and-try method had to be resorted to many times even when those in charge realized that success by this method of design could hardly be loked for. Cut-and-try methods are seldom justified in any experimental work even under the stress of war. They rarely produce quick results in the solution of difficult scientific problems. Such was the situation when the work was started. Much delay was experienced in the procuring of good workmen who were capable of handling the production side. Money and material were often held up but the most difficult of all was the constant striving for the solution of difficult scientific problems with practically no data to work with. Such as we had was derived from hasty experiments or from theoretical calculation based upon obscure assumptions.

In the face of all these difficulties much progress was actually made in this field. It is unfortunate however, that the efforts of the Ordnance Department were not blessed with results sooner as a good part of the development work was perfected too late to be of use in France. This was a special disappointment to those who did the work. It is some satisfaction, however, to know that these devices will be a certified part of the army ordnance equipment and will be available in case of future trouble. It is certainly not too much to state that had the war lasted but a few months longer we would have given the Germans a few more surprises.

The writer wishes, then, to take up in this article the various illuminating devices used by our army and the Allied armies in the war. Detail description cannot in most cases be given because these things are still of military value to the government. When details are given they will be understood to be very general and it does not follow that the way described is the way a certain thing is carried out or accomplished. It will merely be *a* way of doing the thing and not necessarily *the* way it is done.

Illuminating devices may be divided into three general classes of rifle lights, illuminating drop bombs and illuminating shell. Each of these will be discussed separately.

THE RIFLE LIGHT.

The rifle light is designed for short range illumination. In shape it resembles the ordinary rocket except that it is heavier and larger. As the name implies it is fired from a rifle and may be fired from a shielded position such as behind a hill or from the bottom of a trench. It may be fired at any angle with the ground, the maximum range being attained when fired at about 45 degrees.

The rifle light consists of a cylindrical steel container about 6 or 8 inches long mounted upon a steel rod. Inside of the steel container is placed a silk parachute and a cardboard container filled with the illuminating mixture. The upper end of the steel shell is fitted with a sheet-tin cap, pointed to reduce the air resistance. This serves to increase the range and also makes a cavity in which the silk parachute is carried. The strings of the parachute, which must be made of very strong light cord, are attached to the top of the container directly below the parachute cavity. The cardboard container is loaded with the mixture under a heavy pressure. This mixture must be of materials or chemicals which will give an abundant supply of light, which will not be consumed too quickly, and will not produce an undue amount of smoke while burning. It is also necessary that such chemicals shall ignite readily by some simple means at the desired time. More will be given later about this important side of the problem.

In the bottom part of the cardboard container a layer of sensitive priming mixture is usually placed to insure ignition of the charge. This was necessary because it was usually impossible to find an illuminating mixture which would ignite easily or a priming mixture which made a good illuminant. Good priming mixtures were often too expensive to use in the whole light. In the bottom of the steel container a small charge of black powder is placed. Next to this and firmly held is a primer and firing pin together with a short delay fuse. The firing pin must of course be held in an unarmed position in a plunger otherwise it would be unsafe in transportation. The whole device must be absolutely fool proof until it is actually fired from a rifle.

ACTION OF RIFLE LIGHT.

A blank service cartridge is placed in the .30 caliber service rifle. This means that the cartridge is fully loaded with powder but the bullet has been removed. The long steel stem of the light is placed down the muzzle of the rifle and everything is set to shoot. The rifle could be held from the shoulder but this is usually not necessary and it is commonly held at the desired angle by means of a wood frame. The rifle is fired. The pressure of the burning powder gases in the gun eject the light at a high velocity, though naturally a velocity is much less than that of the service bullet because of the greatly increased weight which the pressure is called upon to accelerate. This linear acceleration produces what we call "set back," or inertia force. This force arms the plunger and brings the firing pin into contact with the primer cap firing the latter. This cap in turn ignites the delay fuse. This action is sometimes aided by a small wisp of guncotton. While the delay fuse is burning the light is mounting higher and higher in the air. If properly designed the fuse will just burn through when the light reaches the top of its trajectory. The base charge of black powder is then ignited which creates sufficient pressure to eject the cardboard container and parachute from the steel container. The stem and steel container now being free merely fall to the earth. The parachute and attached light however start to fall but the parachute soon opens under the action of the air pressure and the container slowly falls to earth. The black powder charge besides ejecting the contents of the steel container also ignites the primer mixture which covers the body of the illuminant. The heat from this primer is sufficient to insure the ignition of the main charge.

To be effective the light must be very intense. Rifle lights are designed to burn about 30 seconds. They are apt to vary considerably in practice.

Rifle lights are very destructive to the rifle. Much experimenting had to be carried out in order to determine the proper stresses to allow in the barrel when this device was used. This question formed the basis of an extended set of experiments by the Frankford Arsenal staff. The standard powder pressures had to be greatly reduced. Even at the present time rifles are short lived when rifle lights are fired from them. Rifle firing pins are quickly put out of action. The reason for this excessive stress is to be found in the exceptional weight of the device when compared with the service bullet.

Rifle lights were not known before the present war. They were designed and perfected to meet the actual needs of the service in France. Our army had no such device when we entered the war but fortunately the experimental department at the Frankford Arsenal were able to develop one quickly. This light proved very effective, was adopted by the government and manufactured in quantity. Thousands were made at the arsenal alone. The illuminating mixtures used in these lights were very similar to those used in shell and a general discussion of this point will come later under its own head.

The range of the rifle light is of course very limited. At best it cannot cover a distance of more than a few hundred yards. At this short range it is quite apt to give the enemy as much information about you as it gives you about the enemy. Great care had to be exercised in the use of these lights for this reason. The sender however, has the advantage, as he knows when to expect it and can take such cover as may be available. If short illumination only is desired the angle of fire may be reduced so that the light bursts low, thus reducing the time of fall of the burning case.

ILLUMINATING DROP BOMB.

Why this device is called a bomb has never been clearly shown. It is true that it resembles a high explosive drop bomb in shape and also in the manner in which it is thrown and used. Here the comparison would seem to end. The illuminating bomb carries no high explosive as its function is purely one of illumination.

The illuminating drop bomb is of course used only from aeroplane or balloon. It is used either as an aid to the aviator who has thrown it or to a distant range finder who is counting on it to locate the enemy battery. Its range of usefulness is unlimited. When properly designed it is a great aid to the flier in hitting his mark at night. As stated before the Germans were the leaders in this development work. The Allies were not slow to see the great advantages of such a bomb and very soon had several designs perfected. The problems to be solved in connection with an illuminating drop bomb cannot compare with those met with in shell design. They are simple indeed in comparison. There are practically no forces to be contended with. The bomb does not rotate as does the shell and there is very little inertia force present. The problem resolves itself then into one of finding a suitable illuminating mixture and primer. The mechanical design of case and containers is simple.

Illuminating bombs are of many different designs. In general however they consist of a steel or perhaps an aluminum case. Within this case a large silk parachute and mixture container are placed. A black powder charge, primer and delay fuse must be incorporated as in the rifle light. In this case everything will be on a much larger scale. When the aviator releases the bomb he must do something to fire the primer and ignite the fuse. There are of course many ways in which this might be done. The act of releasing might be made to bring the firing pin and primer together. It could even be lighted with a match but this method would hardly be appropriate several thousand feet in the air and traveling at a high rate of speed. The aviator must be called upon to do as little as possible. It must be practically automatic in its action. Experience has shown that, when it is necessary for the soldier to pull a pin or throw a lever, the inevitable outcome is failure to pull the pin. This is a natural result especially when excitement prevails.

The path of the bomb to the earth is not vertical as many people still suppose. If it only were it would

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be much more easy to hit a target on the ground. Perhaps it is fortunate that this is not the case because sometimes the Germans missed the hospitals and unfortified cities at which they were aiming. The actual path of the bomb is a very complex curve. For our purpose here it is enough to state that the velocity and direction at any point in the downward path is the resultant between the horizontal velocity initially given it by the plane and the vertical velocity being constantly given it by the force of gravity. The horizontal velocity is being constantly reduced by the air pressure while the vertical velocity is increasing. The result is that the trajectory of the bomb becomes more and more vertical as it falls and if the plane from which it was thrown was high enough in the air the path would finally be a vertical line to all intent and purpose. How high the plane would have to be for this to happen is a question of higher mathematics. It will vary greatly under different conditions met in practice.

The delay fuse must be of sufficient length to make the bomb ignite a safe distance below the plane. This distance will of course vary with the altitude of the machine. For this reason the length of the fuse should be adjustable at the will of the aviator. If the fuse were too long the bomb would be so close to the earth before it functioned that the effects would be lost.

As the bomb actually goes forward when released and in the same direction as the plane it is evident that when the bomb ignites it may still be almost directly below the machine. This may be both an asset and a liability. If the bomb is thrown for the purpose of viewing the ground from the machine it may prove an asset. On the other hand if the enemy spies the plane by means of the light it may not be to the aviator's advantage to have it directly below him.

The illuminating drop-bomb functions much the same as the rifle light. The fuse ignites a charge of powder which ejects the parachute and illuminant from the outer case. The air quickly catches the silk and from this point on the whole mass falls more slowly to the earth. This rate of fall may be varied within certain limits by varying the ratio between the weight of the container and the area of the parachute. The parachute is usually made with a central hole through which the air may pass. This arrangement is the same as used on the man-size parachute and is for the purpose of preventing undue swaying of the mass. Such swaying might ignite the parachute and would be sure to reduce the illuminating efficiency.

ILLUMINATING SHELL.

Illuminating shell are by far the most important class of devices designed to aid the soldier. They may be classified as to caliber or according to design. For example we speak of the 3-inch or 6-inch illuminating shell, or we may refer to the parachute or the non-parachute type. Under the first classification we learn nothing about the design of the shell but may get a good idea of the purpose for which is was developed. The second method tells us something about the design and also gives us an idea of how the shell operates.

The more important type from the point of view of range of usefullness is the parachute type of illuminating shell. It may be used under a wide range of conditions and for various purposes. The non-parachute design on the other hand is of special value where short illumination is desired. This shell is also much more efficient than the other type. It will be best here to take these two types up in detail leaving the reader to draw his own comparisons or contrasts between them. In many respects they are not comparable as they are designed for a different class of work.

PARACHUTE ILLUMINATING SHELL.

Parachute illuminating shell are needed by a field army in the following three calibers or their equivalent: 3-inch, 6-inch and the 4.7-inch. The 6-inch is practically the largest required at the present time. These shell may be fired from either gun or howitzer depending upon the range desired. The howitzer is more often used with the six-inch and the gun or the anti-air craft gun with the three-inch. The 4.7-inch has not as yet been extensively used. These three calibers cover the desired range at the present time in a satisfactory manner.

As in the case of other illuminating devices developed for use in the great war foreign governments were far ahead of the United States in star-shell design. English and French designs appeared on the battle front before we had even thought about developing such a shell. Most of these foreign designs were of the parachute type and were in most instances crude affairs. Like ourselves they were forced by necessity to get them quickly and no time was available for refinements.

All parachute star-shell had many things in common even though they differed much in detail. All were designed for the same work and the variations were in most cases merely different designers' ways of doing the same thing. Because of this similarity it is possible to give here a more or less detailed description of the designs without giving away any so-called military secrets. These designs are now a matter of quite common knowledge.

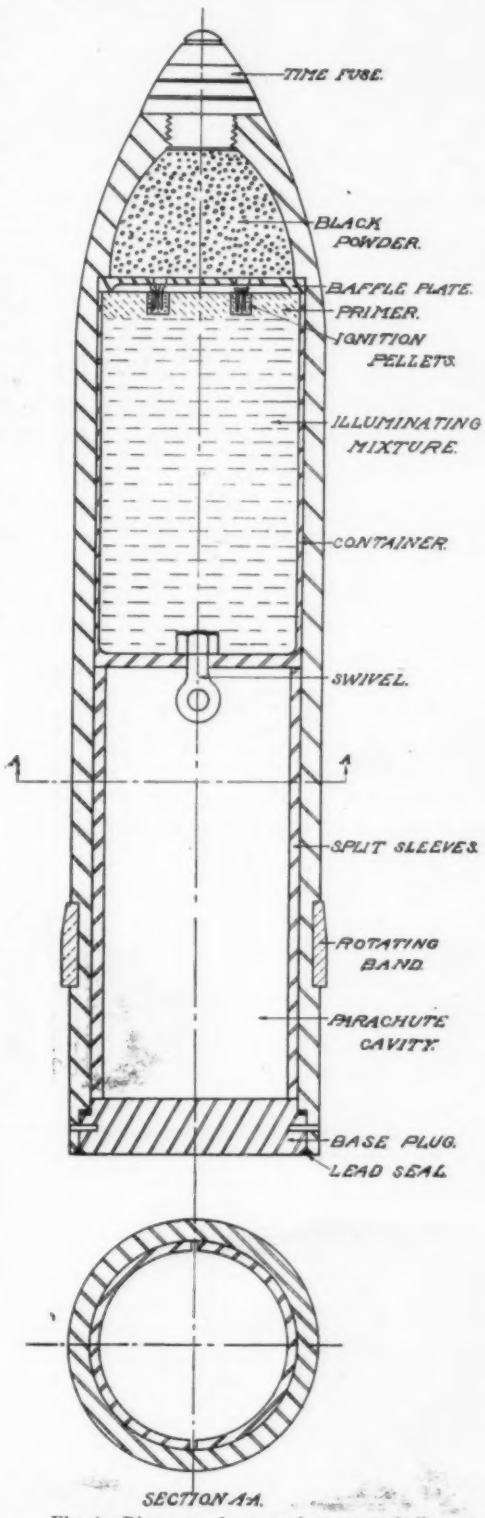


Fig. 1—Diagram of a parachute star-shell

Figure 1 gives a section of such a shell. This sketch is made somewhat diagrammatic and no attempt has been made to give details. These would vary so much in the different shell now used that it would serve the purpose of this article no more that way. The shell consists of a hollow steel body bored with a straight interior. The standard high explosive shell will serve for the purpose in most calibers. In specifying the interior bore care must be taken to see that too much metal is not removed thus weakening the shell at the base. This should be carefully calculated by a ballistic engineer. Into this cavity is fitted a steel container to which is attached a large parachute. This container is sometimes made of cardboard in the smaller calibers. The parachute is attached to the container by means of a swivel. This is for the purpose of preventing the ropes from becoming entangled as the shell rotates in the air or while it is being ejected. The parachute is placed in the end of the shell opposite to the container and in the sketch this is the base. This order is often reversed. Around the parachute is placed a split sleeve of steel as shown. The cross section shows this longitudinal seam. The base is closed by means of a steel plug. This plug must be securely fastened in place and yet not held hard enough to prevent coming out when the shell functions. This is accomplished by say two small shear pins placed perpendicular to the axis of the shell as shown. These pins serve merely to hold the plug in place. Two or four larger pins, depending upon the caliber of the shell, are placed parallel to the axis of the shell half in the plug and half in the shell itself. These pins are not shown on the sketch. When the shell is fired these twist pins take all the stress and do not prevent the plug coming out at the time desired.

The shell is fitted with the ordinary time fuse. A large charge of black powder is placed in the cavity of the nose. Over the end of the steel container is placed a steel disk which is drilled in several places. The container is filled with the illuminating mixture under pressure. This mixture is usually difficult to ignite readily and so it becomes necessary to take special precautions to insure ignition. The last layer is a more sensitive mixture and into this are usually pressed several powder pellets having a stem of quick match in their center. This quick match is usually made from cotton fiber dipped in a mixture of meal powder and shellac. Sometimes threads of guncotton are used. This kind of quick match is apt to be too fast for this purpose. These pellets are pressed into the top layer of the primer in the final pressing, the die being arranged for this operation. The center stem of quick match is allowed to project above the surface and either extends through the holes in the cover disk or is bent over the top thus presenting a large surface to the flame. It must be kept in mind that the one purpose in all this construction is to get the illuminating mixture to ignite. This has proven one of the most difficult problems in this development work.

The action of this shell during the period in the gun and in flight is as follows. The heavy linear and angular acceleration in the gun tend to force all parts toward the rear as well as to turn them relative to the body of the projectile. In the design shown here no attempt has been made to prevent relative rotation it being assumed that such rotation would do no harm if it did take place. It is probable, however, that the friction set up at the base of the sleeve and where the container rests upon the sleeve is sufficient under the heavy set back to prevent relative rotation. Some designs incorporate longitudinal rods where rotation would cause trouble. These should be avoided where possible as they take up room and only add to the complication. During the period in the gun nothing should happen except the proper functioning of the time fuse which has previously been set at the time which it is desired to have the shell function. This also holds true during the flight of the star shell; the only happenings should be the burning of the powder train in the fuse. At the instant the fuse train burns through and the base charge explodes things begin to happen.

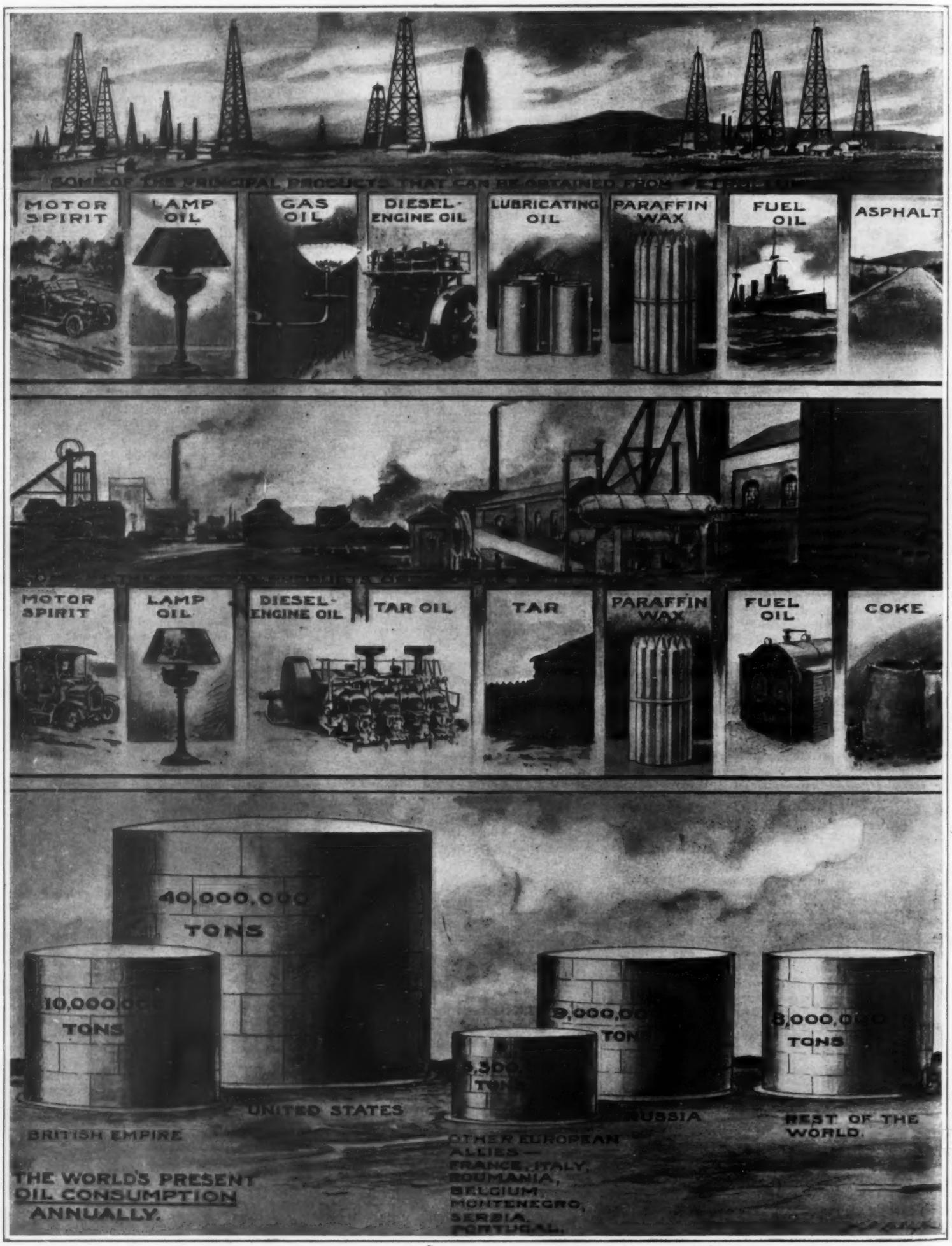
The flash from the base charge in the time fuse sets off the charge of black powder in the nose of the shell. This creates a heavy pressure which is transmitted down thorugh the container and the split sleeves to the base plug. It is here that these lateral pins must not be too strong. The pressure in the nose must be sufficient to shear the pins and eject the whole contents into the air. The empty body must travel on and ultimately fall to earth. Due to the rotation the split sleeves very quickly fall free from the parachute and this together with the attached container start to fall. The air should quickly catch the parachute and open it. From this point on, if the shell has functioned properly, the mass should fall slowly. The high temperature and flame created by the nose charge of powder sets fire to the quick match stems which in turn ignite the primer. This should be well ignited when the contents reach the air. If not the sudden rush of air is very apt to put it out and the whole desired effect is lost. Poor contact between the layer of priming mixture and the body will also prevent ignition of the latter. A primer to be absolutely certain must have a temperature of burning far above the ignition temperature of the main mixture.

The time of burning varies with the different designs and with the different calibers. Usually about thirty seconds is obtained. The time of burning and the il-

(*Continued on page* 127)

Oil and Coal: Oil Consumption: Dwindling Coal Output

Drawn by W. B. Robinson from Material Supplied by J. T. Smith, Editor of *Oil News* (London)



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Similar products obtained from oil and coal, and the world's consumption of oil (see p. 119)

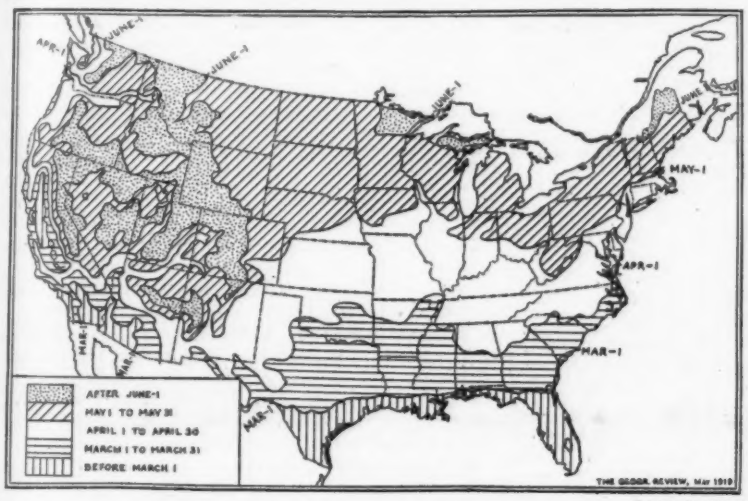
Frost in the United States*

Important New Frost Maps in the "Atlas of American Agriculture" and What They Show

By Prof. Robert De C. Ward, Harvard University

THERE have been three general stages in the charting of our knowledge of frost occurrence in the United States. In the earlier maps the average dates of the first and the last killing frost were based on records obtained at regular Weather Bureau stations.[1] In all these maps the lines of equal frost dates were left incomplete over much of the West, owing to lack of adequate information, but in the later maps of this first stage (1906) the average dates of the first and the last frost were entered at certain Weather Bureau stations over the Western plateau and on the Pacific Coast although the lines themselves were not drawn. The information given on all these maps was obviously based on very insufficient data. Observations at regular Weather Bureau stations, which are located chiefly in large cities, do not show actual conditions of frost occurrence over the rural farming districts and are too few in number for accurate generalization.

A second stage was reached when, in addition to the data obtained at the regular stations of the Weather Bureau, observations made by co-operative observers, widely scattered over the country, were also taken into account. By the inclusion of these additional data a much more accurate and more complete view of frost conditions was gained. Maps based on this larger series of observations, including those made at approximately 1,000 co-operative observers' stations having the longest records (usually about 10-30 years), were published in 1911.[2] This investigation included maps of the average dates of the first and the last killing frost; of the earliest and latest dates on which killing frosts have occurred in fall and spring respectively; and of the average length of the crop-growing season. This new set of maps brought out, much more clearly than had been done before, the influence of local conditions upon frost occurrence. Lines were drawn for the Eastern sections, while dates only were still used over the Western mountain and plateau districts and on the Pacific Slope.



Courtesy American Geographical Society

Fig. 1—Average dates of last killing frost in spring

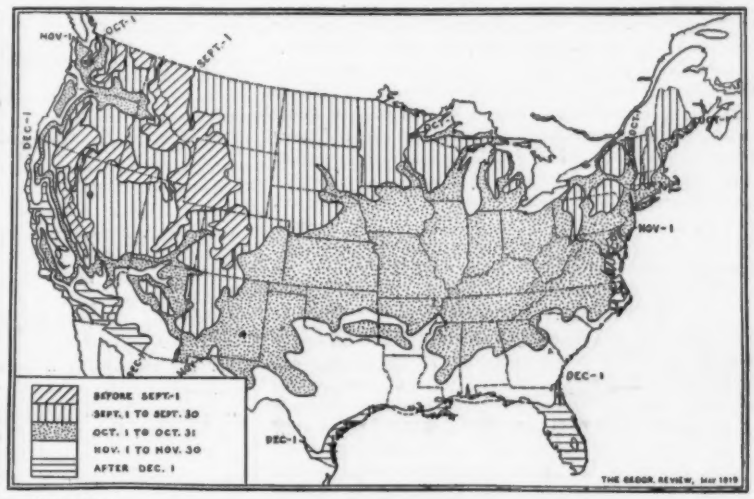
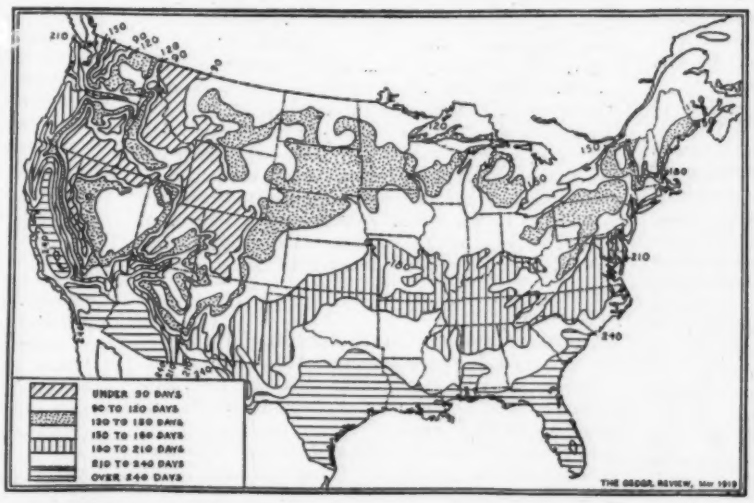


Fig. 2—Average dates of first killing frost in fall



Courtesy of American Geographical Society

Fig. 3—Average length of the growing season in days

THE NEW MAPS OF THE "ATLAS OF AMERICAN AGRICULTURE."

A third stage has been reached in the recent publication of the very valuable and comprehensive study of frost which forms Section 1 of Part II of the "Atlas of American Agriculture." Frost records are now available from about 4,000 regular and co-operative stations of such critical significance. For frost to occur, the general weather conditions must be favorable. These are now reasonably well understood, as the result of long experience in forecasting. Type maps, characteristic of frost weather, may be selected for the various sections of the country (Figs. 6-15 of the atlas). These are very useful for purposes of local frost study and in general teaching. Indeed, the investigation of frost, to be really useful, must be highly intensive and very local. Every area has, in a sense, its own special and peculiar frost conditions and needs its own special "thermal survey."

The traditional frost maps give the average dates of the last killing frost in spring and of the first killing frost in autumn. To these is usually added a chart showing the average length of the growing season, between the first and last frost dates. In the present monograph far more detail is included. By reference to the mean daily minimum temperatures for any station it is easy to determine the date on which, in the general course of the seasonal decrease of temperature in autumn, this minimum falls below freezing. Similarly, in the spring, the average date on which the mean daily minimum rises above freezing may be determined. If first and last frosts came regularly on these dates, the whole frost problem would be perfectly simple. Frost, however, is characteristically variable in its dates of first and last occurrence. Cyclonic and anticyclonic spells of colder or warmer weather, coming irregularly and without much regard to the normal seasonal temperature curve, easily advance or retard the actual dates of the first and the last frost. Thus it is that there are likely to be considerable departures from the average dates, and a complete study of frost must include a consideration of these variations.

NATURE AND OCCURRENCE OF FROST.

Frost is not a simple phenomenon. It appears in varying degrees of severity ("light," "heavy," "killing"), and the line between these is not easily drawn. A frost of a certain type of severity does not necessarily cause the same amount of injury to all kinds of vegetation. Temperatures low enough to injure plants often occur without any frost deposit. Again, frost is characteristically "patchy" in its occurrence. Given generally favorable weather conditions, its actual occurrence is largely a matter of topography and of air drainage. Frosts in winter have little or no economic importance except in the South and the Southwest. In summer they do not occur execept in certain elevated areas. Thus it is that spring and autumn frosts are

THE LAST KILLING FROST IN SPRING.

The atlas includes two double-page maps, in color, showing the average dates of the last killing frost in spring and the first killing frost in autumn, based on the 20-year period, 1895-1914 (Figs. 3 and 20). On the first of the two lines are drawn for the first, eleventh, and twenty-first day of each month from March 1 to June 1 over the areas east of the Rocky Mountains, and from the Rocky Mountains westward for the first of each month only. The accompanying figure (Fig. 1) has been simplified and generalized by the present writer from Figure 3 in the atlas. It gives the essentials, not the details, of the original map. The general east-west trend of the lines in the East shows that latitude is here the chief control, although the deformation due to large bodies of water and to topography is also obvious. In the West altitude and the influence of the Pacific Ocean are the chief controlling factors. In view of the complex topographic controls over frost occurrence in the West and of the further fact that the

*Reproduced from *The Geographical Review* (New York), by courtesy of American Geographical Society.

[1] A. J. Henry: Climatology of the United States, *U. S. Weather Bur. Bull. Q.*, Washington, D. C., 1906, text, pp. 33-34. Pls. XIX and XX. See also previous charts in A. W. Greely: American Weather, New York, 1888, pp. 269-270, frontispiece and Chart XXIII. These maps were reproduced in F. Waldo: Elementary Meteorology, New York, 1896, pp. 333-335; Figs. 103 and 104.

[2] P. C. Day: Frost Data of the United States and Length of the Crop-Growing Season. As Determined from the Average of the Latest and Earliest Dates of Killing Frost, *U. S. Weather Bureau Bull. V*, Washington, D. C., 1911.

[3] W. G. Reed: Frost and the Growing Season, Pt. II, Sect. 1, Atlas of American Agriculture, prepared under the supervision of O. E. Baker, Office of Farm Management, U. S. Dept. of Agriculture, Advance Sheets, 2, issued July 15, 1918, 12 pp. folio.

reporting stations are mostly at the lower levels, it is impossible to draw lines with great accuracy or detail.

The earliest date shown on the map is March 1. The area over which frost does not occur annually includes the southern half of Florida; the immediate coast of the Gulf of Mexico, and that of southern California. Killing frost occurs in fewer than half of the winters in southern Florida and in the region around San Diego. Excepting Key West and some of its neighboring keys, frost has occurred in all parts of the United States. Over about one-eighth of the country, i. e. along the northern boundary and at the greater elevations in the West, the average date of the last killing frost in spring is after June 1.

VARIATIONS IN THE DATES OF SPRING FROSTS.

As indicated above, the actual date of the last killing spring frost is likely to depart very considerably from the average date. Hence the need of study of the variations in the dates of spring frosts. This has been carried out, as fully as is now possible, in the present monograph. A colored map (Fig. 16), based on 700 records, indicates the number of times in the twenty years, 1895-1914, that the last killing frost in spring was ten days or more later than the average date. This map, therefore, gives a measure of the variability of the dates of the last killing frost. These variations are, as a rule, smaller near the Atlantic coast and over the strip of country just east of the Rocky Mountains and are greatest to the west of the Rocky Mountains, where the local effects of the varied topography are most marked, and in Florida and along the Gulf Coast. Another map (Fig. 23) shows the dates after which killing frost in spring is likely to occur only one year in ten on the average, i. e. where the chance falls to 10 per cent. In the West, in Florida, and on the Gulf Coast, the chance of killing frost falls to 10 per cent about thirty days later than the average date of the last killing frost in spring.

THE FIRST KILLING FROST IN FALL.

Figure 2 is a simplified and generalized reproduction of Figure 20 in the atlas. It shows the average dates of the first killing frost in the fall. The general similiarity between Figures 1 and 2 as here given is easily seen. Thus, the region over which the average dates of the first killing frost are earlier than September 1 is about the same as, though somewhat smaller than, that over which the average dates of the last spring frost are later than June 1. The effects of the Great Lakes in delaying the date of the first killing autumn frost are clearly seen. As in the case of spring frosts, above noted, two maps are given in the atlas which show the variations in the dates of the first autumn frost (Figs. 18 and 26).

AVERAGE LENGTH OF THE GROWING SEASON.

Figure 3 is a simplified and generalized reproduction of a double-page colored map (Fig. 29) showing the average length of the period between the average date of the last killing frost in spring (Fig. 3 of the atlas) and the average date of the first killing frost in the fall (Fig. 20). At Key West, Fla., the growing season is 365 days long; in the higher parts of the West it is less than 90 days long. The region with an average period of less than 90 days without killing frost is mostly not available for general farming. Forests are found there when there is sufficient rainnfall. The length of the growing season naturally varies considerably from year to year, with the fluctuations in the dates of frost occurrence. Therefore a map has been constructed (Fig. 27) which shows how many times in the twenty years 1895-1914 the season without killing frost was 15 days or more shorter than the average. This indicates the variability of the frostless season in different parts of the country. In this same connection, another map (Fig. 32) shows the approximate length of the season available for the growth of many crops in about four-fifths of the years. This gives, in general, "the number of days expected to be available for the growth of crops in a sufficiently large proportion of the years to enable the organization of farm enterprises on that basis with a reasonable chance of success."

IMPORTANCE OF THE ATLAS.

In the foregoing, reference has been made to some of the more important and most generally useful portions of the new study of frost. Enough has been said to indicate the wealth of detail which is included and to show what a very distinct advance has been made in our understanding of frost conditions in the United Sttes. A comparison of these latest frost maps with the earlier ones referred to at the outset of this review is well worth while as emphasizing the progress made within the last three decades. Mr. Reed's discussion contains numerous other diagrams and maps, mention of which is impossible here, and also an excellent bibliography.[4] Throughout the investigation, the needs of the farmers of the country have been kept constantly in mind. The intelligent use of the facts of frost occurrence available in the present monograph will be of the greatest economic value to our agricultural interests.

Clouds Induced by Forest Fires*

By Ford A. Carpenter

THE spectacle of a cloud-crowned smoke column is not an unusual sight in southern California. Notwithstanding alert forest protection, fires in the timber or chaparral are not uncommon during the long rainless summers of this region. The heat during such fires is intense and concentrated owing to the conflagration being limited to a relatively small area. They, therefore, induce strong vertical convection.

During the past five years a number of examples of local convection resulting from forest fires in southern California have come under the writer's notice. They have many attributes in common, and yet they possess considerable individuality.

Example No. 1.—This cloud has already been described in the *Review* as follows:[5]

On August 23, at 3:48 p. m., a brush fire in the northern foothills sent up a straight column of smoke. When the fire reached its maximum intensity a small but well-developed cumulus cloud was seen to cap the ascending column. When the smoke column disappeared the cloud lasted two or three minutes. It was an interesting instance of cumulus cloud formed by ascending currents. The sky was free from cloud all day except for this solitary cumulus, which had an existence of less than five minutes.

Example No. 2.—One of the fiercest forest fires in this district, but one which covered a relatively small area, occurred on the morning of September 13, 1913. This fire destroyed the forest cover of Sister Elsie Peak (15 miles north of Los Angeles). In the case of this fire the writer was so near it as to be able to note many of its features. The notes made at the time state that a smoke column was observed ascending over the northwestern horizon. This pillar of smoke mounted steadily to a great altitude, and in a short time was capped by a well-defined cumulus cloud (see p. 113). Up to the hour of the appearance of the smoke column, the sky was free from clouds, the day being unusually hot, the thermometer registering 90°F. as early as 8:30 a. m., and remaining above 90° until 2 p. m. About 10 a. m. the fire-caused cloud mushroomed, and within an hour the western portion of the sky became filled with cumuli extending in uniform thickness to the seacoast beyond. The photograph of the smoke and cloud above Sister Elsie Peak (elevation 5,080 feet above sea level) was made from Echo Mountain, which has an elevation of 3,500 feet above sea level. The very rapid changes in the structure of the column made a focal-plane exposure necessary. The exposure was about 0.001 second at 10 a. m. The most striking feature of the cloud was the well-defined mantle (scarf cloud)[2] which formed after the cloud mushroomed. This marked the dividing line between the smoke and the ensuing cloudy condensation.

Heights of Cumulus Clouds Forming Over Fires*

By S. P. Fergusson and C. F. Brooks

APPARENTLY very few measurements have been made of the height or movement of cumulus clouds over fires. The writers know of but six instances of the kind, and since they are of unusual interest to students it seems desirable to present a brief account of the formation and heights of these clouds.

The first example is a measurement made by A. E. Sweetland and S. P. Fergusson of two small cumulus clouds forming over a fire which destroyed the Bay State Iron Works, in South Boston, June 30, 1899.[3] On this date the weather was fair, the sky nearly cloudless in the afternoon, and the surface wind very light and from a westerly direction. The fire began shortly before 8 p. m. and the smoke-cloud was not of unusual size, but rose vertically to a considerable height (800 to 1,000 meters), encountering at this height a northwesterly wind, which swept it nearly horizontally over Boston Harbor. The smoke reached its greatest height about 8:05 p. m. At 8:03 p. m. a small white cloud began to form at the apex of the smoke, which at this time was nearly over Long Island, in the harbor. This cloud increased rapidly in height, assuming the form of a true cumulus, and reached its greatest dimensions at 8:05 p. m. It was about 3° in height and length, the highest or thickest end being toward the north. Between 8:05 and 8:07 p. m. another, smaller cloud formed at the eastern edge of a rift in the smoke considerably lower than the first and about 5° farther north. Mr. Sweetland, at Winthrop, 8 kilometers northeast of the fire, estimated the altitude of the higher cloud to be 15°, while a measurement with nephoscope by Mr. Fergusson at Blue Hill Observatory, 16 kilometers south of the fire, gave 10° as its altitude as seen from the observatory. These measurements show that the higher of the two clouds was at least 2,500 meters, while that of the lower was about 2,000 meters, above sea level.

The smoke began to diminish in quantity at 8:07 p. m. and separated from the clouds, which became flatter and more elongated. At 8:11 they separated from the smoke by a space of several degrees wide, and after this time they slowly evaporated.

During the conditions prevailing on June 30—relatively dry air and clear sky—the level at which cumulus will form is higher than usual, but at or after sunset, when the fire occurred, the level where condensation in air rising from the surface would occur must have been considerably lower. At the Boston office of the Weather Bureau at 8 p. m. the temperature of the air was 19.7° C. and the dewpoint 6.7° C. Under forced ascent and adiabatic cooling, air with this temperature and dewpoint would become cloudy at about 1,700 meters above sea level [$H_m = (t_a - t_{dp})/0.007$ Therefore, it appears that the fire caused clouds to form some 300 to 800 meters higher than might otherwise have been the case.

The next instance occurred on April 12, 1908, during the great conflagration in Chelsea, Mass., when more than 2 square miles of city blocks were consumed. The fire began about 11 a. m. and the clouds formed between 2 and 3 p. m., when the column of heated air was at its maximum extent.

The sky was cloudless, the temperature in the afternoon was 7°C. (or below normal), the relative humidity was very low—14 per cent—and a strong gale blew from the north-northwest. The column of smoke was of immense size, and at its highest point, situated over Boston Harbor some 19 kilometers from Chelsea there formed a succession of flat, white cumulus clouds, which after drifting farther to leeward, slowly dissolved as they sank into a warmer stratum, because no longer supported by the rising column of heated air.

Approximate angular measurements, made at Blue Hill Observatory by Mr. L. A. Wells and in Boston by Prof. A. L. Rotch, gave the minimum height of these clouds between 4 and 5 miles (average, 7,200 meters). Their relative velocity, compared with the surface wind, also indicated that they were much higher than the ordinary cumuli which float at the level of about a mile (1,609 meters). Mr. Fergusson discussed these observations with Prof. Rotch at the time, and although the altitudes were estimated, both observers were accustomed to making such estimates; and while almost all estimates of altitudes are too high, it does not seem likely that the height given is more than 1,000 meters too great. During the conditions prevailing on the afternoon of April 12, 1908, the potential height of the bases of cumulus clouds, computed from the depression of the dewpoint, was about 3,500 meters. Hence, we have in this a good example of a cloud forming artificially at nearly twice the height it should form under natural conditions.[1]

A third example occurred on October 21, 1908, when the column of heated air was not of itself sufficient to form clouds of appreciable size, but caused a rapid increase in dimensions of small fracto-cumuli drifting over the fire. On this occasion a large barn about 2 kilometers east of Blue Hill Observatory was consumed. The contents, chiefly hay and straw, burned with great intensity, the flames rising 30 meters above the building. The fire began at 1:15 p. m. and reached its maximum intensity at about 1:45 p. m. On this date the temperature was below normal and a moist sea breeze of about 7 m./s. was blowing from the northeast. A few small fracto-cumulus clouds were floating in this

[4] A "Selected Bibliography of Frost in the United States," by W. G. Reed and Cora L. Feldkamp, will be found in the *Monthly Weather Rev.*, Vol. 43, 1915, pp. 512-517. Two additional recent papers by W. G. Reed have been published as follows: Outline for the Study of Frost and Protection against Frost Damage, *Journ. of Geogr.*, Vol. 14, 1915-16, pp. 54-55; Protection from Damage by Frost, *Geogr. Rev.*, Vol. 1, 1916, pp. 110-122. A selection of books and papers bearing on frost forecasting was printed in "Weather Forecasting in the United States," U. S. Weather Bureau, Washington, D. C., 1916, pp. 357-358 (*Weather Bur. [Publ.] No. 583*). An important study of the occurrence of frost over the earth as a whole is that of Otto Dorscheid: Die mittlere Dauer des Frostes auf der Erde, *Meteorol. Zeitschr.*, Vol. 42, 1907, pp. 11-24, 49-64 (with maps of frost dates).

*Reprinted from *U. S. Monthly Weather Review*.

[5] *Monthly Weather Review*, 1912, 40: 1258.

[2] See *Monthly Weather Review*, 1917, 45: 361-363.

[3] *Science*, New York, July 12, 1899, p. 86.

[1] This cloud was described by Prof. Rotch in *Science*, May 15, 1908, pages 783-784.

wind at a height, determined by observations of their shadows, of about 1,000 meters. The observations and a sketch were made at the time by Mr. Fergusson.

At 1:20 p. m. a few distinct nuclei were observed in the upper surface of the smoke cloud and between this time and 1:50 p. m. the number varied from one or two to more than 10. At 1:35 p. m. a small patch of fracto-cumulus on drifting into the smoke rapidly increased in density, a shell of cloud forming outside the original cloud, and which slowly united with it. At 1:40 p. m. the small cloud was double its original size, after which it diminished, disappearing at 1:55 p. m. The height of this cloud, observed by means of a transit, was about 1,100 meters, or slightly higher than the clouds in the free air at a distance from the fire.

The fourth example also was obtained at Blue Hill Observatory, by C. F. Brooks on July 22, 1913, when a large cumulus formed over a burning fertilizer factory in Weymouth, 16 kilometers east-northeast of the observatory. The fire began at 3:35 p. m. and the smoke cloud reached its maximum intensity at 3:47 p. m., rising at an apparent angle of 33° to 38°. The cumulus cloud appeared at 4 p. m. and disappeared at 5 p. m. Photographs were made at 4, 4:03, and 4:15 p. m. The following observations were made with a transit:

	Summit of cloud		South'n edge
Time	4:25 p. m.	4.3 4.65 p. m.	4:35 p. m.
Altitude	5.4°	-4 °	3.1°
Azimuth	250.5°	8.5°	261°
Probable dist. of cloud	17 km	km	18 km
Height above sea level	1,800 meters	0 meters 1,70	1,200 meters

Azimuth of fire, 254°; direction and velocity of wind, S. (360°), 7m./s.

The temperature at Blue Hill was about 25° C. At 8 p. m. it was 18.9°, the dewpoint 16.7°, and the maximum of the day 28.3° C. Therefore, the height of the potential cumulus base was about 1,000 meters above Blue Hill, or 1,200 meters above sea-level. Thus, the fire-formed cloud seems to have been but little, if any, higher than the elevation at which clouds would have formed naturally.

The fifth example was observed at Lindenberg, Germany, on July 29, 1917, by Dr. H. Hergesell, and a description with a photograph was published by him.[2] On that date a large forest fire occurred and the smoke cloud, mounting to 1,255 meters, became limited, for the most part, by an inversion of temperature (observed by kites at 1,100-1,200 meters). Over the hottest part of the fire, however, the upcurrent was warm enough, with the aid of the latent heat from condensation, to push through this limiting inversion layer and to form a cumulus cloud with an apex rising to 1,800 meters.

The last example is that given by Mr. Reichelt.[3] The height of the base of the cloud observed was about 1,500 feet and that of the top 2,500 feet (approximately 450 and 750 meters, respectively). From the data as to temperature and humidity given, the height of the potential base of cumulus clouds at that time was 750-850 meters. Thus it seems that the moisture contained in the burning leaves added so much humidity to the air that even at the high temperature of the rising column, condensation took place appreciably lower than would have resulted from fireless convection.

From these examples, it appears that the height at which cumulus clouds will form over fires depends largely on the dryness of the hot air ascending from the fire; and, therefore, that the height of the cloud base is generally greater over burning buildings than the height of the potential base if there were normal convection, but less over burning leaves or other material containing much water.

Oil and Coal as Rivals*

By J. T. Smith, Editor of "Oil News"

It is rather remarkable, considering that oil and coal are generally looked upon as contrasting fuels, that the products we can obtain from them are so similar. In this country most coal is used in its solid form as fuel to raise heat or to obtain steam; but in other countries, and particularly in Germany, coal is distilled, so as to obtain from it a number of valuable products.

The diagrams on page 116 show some of the principal products that can be got from petroleum, and also those that can be got from coal. The petrol used to propel motor cars is counterbalanced by the benzol got from coals, which can be used for the same purpose. The paraffin oil used in our lamps (or something very similar) can also be obtained from coal.

Gas-oil, which is a petroleum product used for enriching coal gas, is very similar to a product that can be obtained from coal. Good fuel-oil can be got both from petroleum and from coal. It is, of course, well known that the principal part of the Navy's fuel oil comes from American petroleum; but it is not so well known that during the last year of the war a considerable quantity of fuel-oil was obtained in England from cannal coal. In addition to many thousands of cubic feet of gas per ton of coal, there was obtained from this cannel coal (and is still being obtained) about forty gallons per ton of excellent fuel-oil. This oil, when tested under boilers for steam-raising purposes, proved very efficient; and only a technical disqualification prevented it from being used as naval fuel-oil. However, when mixed with fuel-oil of petroluem origin, the mixture was suitable for naval fuel.

For many years past products similar to all the prinicipal petroleum products have been got from a mineral known as oil-shale, some three thousand tons of which is mined annually in Scotland. From this shale we get excellent fuel-oil, good lamp-oil, lubricating-oils, and other liquid products similar to those from petroleum. It is remarkable also that paraffin-wax, which constitutes the ordinary wax candles now in such general use, can be obtained from coal, from petroleum, and from shale.

The distillation of coal, and the turning of it into the numerous liquid products which can be so obtained, is a far more economical manner of using coal than that of shovelling it on to fires or into furnaces.

All oil figures have been upset by the war, and many of the data on which exact statistics can be founded are not available. But we may give the following rough estimate as to the world's annual consumption of oil products:

	Tons.
British Empire	10,000,000
United States	40,000,000
European Allies—	
France, Italy, Roumania, etc.	3,300,000
Russia	9,000,000
Rest of World	8,000,000
Total	70,300,000

The British Empire's requirement is large because of the enormous consumption of oil-fuel by the Grand Fleet during the war. In countries like the United States and Russia, which produce enormous quantities of oil, oil-fuel to a large extent takes the place of coal, and this accounts for the large consumption in those countries. America, for example, consumes at home far more oil than she exports; and, as the export trade of Russia has been practically non-existent since the outbreak of the war, all the oil produced there must be consumed or put into storage. Although the British Empire has to rely mainly on foreign countries for the oil it consumes, there is good reason to hope that in a few years' time we shall be producing that oil from within our own borders. Egypt, North-Western Canada, British New Guinea, and certain other parts of the Empire contain great possibilities in this respect. Much capital and a considerable time will be needed to develop these resources.

Metal Carbides Borides and Silicides and Their Use in Metallurgy

There exist a great number of metal carbides which are obtained in the electric furnace. Some metals, like copper, zinc, mercury, etc., do not combine directly with carbon. Carbides are generally divided into two classes: (1) Those not decomposed by water, such as the carbides of iron, chromium, molybdenum, tungsten, vanadium, zirconium, titanium, etc.; (2) those decomposed by cold water, such as carbide of calcium, aluminium, strontium, barium, lithium, thorium, etc. There exist also double carbides such as those of tungsten and chromium, iron and manganese, complex carbides, such as carbo-silicides, carbo-nitrides, etc.

In the manufacture of calcium carbide the lime employed should contain 99 per cent. of calcium oxide. The carbon should be pure, anthracite or coke being used, sometimes a mixture of both, but preference is usually given to coke, which has a conductivity greater than that of anthracite. Alternating current should be used in the electric furnace. Some furnaces use three-phase current, but the arc and resistance furnace is preferred. The chief use of calcium carbide is the preparation of acetylene. It is also employed to prepare an alloy of copper and manganese (calcium silicide) for dehydrating purposes.

Manganese carbide Mn_3C is obtained in the electric furnace by the reduction of Mn_3O_4 by means of C. This carbide gives, in contact with water, methane CH_4 and hydrogen. Melted with a small quantity of manganese carbonate $Mn\,CO_3$ it gives the pure metal and carbonic oxide. Nickel carbide Ni_3C is formed by the union of the two elements at temperatures neighboring 2,100° C. Aluminium carbide Al_4C_3 is produced by the direct union of the two elements in the electric furnace. It can also be obtained by heating aluminium and calcium carbide in an arc furnace. Zirconium carbide is obtained by the reduction of zirconia by carbon. In the Bohm process for the manufacture of incandescent lamp filaments, the initial material is the hydride of zirconium ZrH_4 obtained by reducing zirconia with magnesium in a current of hydride. Titanium carbide is formed by heating the metal in presence of carbon. Tungsten carbide CW_2 is obtained by subjecting to heat a mixture of carbon, iron and tungstic acid, the carbide being afterwards isolated by chemical reagents. Vanadium carbide VaC is prepared by heating a mixture of carbon and vanadium or vanadic anhydride.

Tungsten-chrom carbide $CW_2 3C_2Cr_2$. This double carbide is a powerful abrasive. It is obtained by heating a mixture of chromium sesquioxide, tungstic acid and carbon. Uranium carbide is used as catalyst in the synthetic manufacture of ammonia, by the direct union of nitrogen and hydrogen at 700—800° under a pressure of from 200 to 250 atmospheres, in accordance with the Haber-Rossignol process.

A great number of metal borides have been obtained in the electric furnace. Tungsten boride WBo_2 is obtained in the electric furnace by heating the two elements. Silicon borides $SiBo_3$ and $SiBo_6$, are formed from their elements. They readily conduct electricity and do not oxidise. Calcium boride is obtained by heating a mixture of calcium borate, aluminium and carbon. Strontium boride is obtained in a similar manner, strontum borate being used. Manganese boride may be prepared by heating a mixture of boric acid and manganese carbide.

Metal silicides consist of copper silicide, ferro-silicon, mangano-silicon, calcium silicide and aluminium silicide.

Calcium silicide is a compound mainly used in electric metallurgy owing to its great reducing power at high temperatures and the ease with which it forms fusible slags. There are two silicides of calcium $CaSi_2$ and Ca_2Si_3.

Silico-aluminium. This is not a compound but more or less an intimate mixture of the two elements. The fusion of silicon and aluminium is effected rapidly by a current 350 amperes at 50 volts. Although silicon and aluminium cannot form binary alloys, they are capable of forming ternary alloys; the so-called silico-aluminides.

Cupro-silicon—Siliceous bronze. Five definite copper Silicides are known: $SiCu_4$, $SiCu$, $SiCu_2$, Si_4Cu_3, and Si_4Cu_{10}, obtained by the reduction of silica by carbon in the presence of copper.

Nickel-silicon. The alloys of nickel and silicon are $SiNi_4$, $SiNi_2$, $SiNi_3$, $SiNi$, and Si_2Ni_3. They are obtained either by the reduction of a mixture of silicon and nickel oxides with charcoal or of nickel oxide alone with carborundum.

Silico-chromium. Four types of alloys of chromium and silicon are known: $SiCr_2$, $SiCr_3$, $SiCr_7Cr_3$, and Si_4Cr. They are obtained by the reduction with carbon of a mixture of chromium oxide and silica.

Silico-manganese also called mangano-silicon is used in metallurgy like silico-spiegel (silicon-iron manganese), and has an advantage over the latter in that it contains no iron or very slight traces of iron.

Five principal manganese silicides are known: $SiMn_3$, $SiMn$, Si_2Mn_3, Si_3Mn, and $SiMn_6$. They are obtained by varyng methods: (1) by the reduction of natural manganese silicate or rhodonite, (2) by the reduction of oxidised ores of manganese admixed with silica, (3) by the simultaneous reduction of silicate and oxide ores.

Silico-manganese-aluminium is largely used in the manufacture of hard steels for guns and projectiles. It can be prepared by running together molten ferro-silicon and molten ferro-manganese separately prepared, and adding molten aluminium.

Titanium silicide. At the temperature of the electric furnace silicon combines with titanium to form a well-crystallised silicide. It is also obtained by allowing silicon heated to 1,400° to act on titanium tetrachloride. The titanium silicides are $SiTi_3$ and Si_2Ti.

Tungsten silicide. It is difficult to obtain silicon-tungsten alloys free from iron in the electric furnace. Three definite tungsten silicides are known: Si_2W_5, Si_3W, and Si_4W. Tungstic acid reduced by carbon in the presence of silica gives Si_2W_5.—*Revue générale de l'Electricité.*

[2] *Das Wetter*, August-September, 1917, pages 178-179.

[3] *U. S. Monthly Weather Review, March*, 1919, 47, p. 144.

*From *Illustrated London News.*

Origin of American Agriculture*

Ancient Pottery Reveals the Invention and Spread of Agriculture in America

By Herbert J. Spinden

[Photographs by courtesy of American Museum of Natural History]

On the foreland of ancient American history the invention of agriculture is the one outstanding fact. For without a sure and abundant food supply, to be secured only by domesticating plants, the American Indians could never have risen above the status of hunters, herders, or lowly fishermen. Agriculture was indeed the indispensable invention that made possible all the higher arts, both in the Old World and the New.

Yet agriculture began independently in the two hemispheres. The plants found under domestication among the American Indians are distinct as a group from those known in Europe, Africa, Asia, and the Pacific islands, before the discovery of America. We have, then, in the New World and the Old two unrelated families of civilization, each dependent upon agriculture, but with unrelated groups of plants as the bases. In each area, the increase in population and the accumulation of wealth that resulted from this conquest of the vegetable kingdom made possible intellectual and artistic expression upon a grand scale.

The idea of agriculture may have had several points of origin in America, but this does not seem likely, since maize, beans, and squashes were common products wherever agriculture was practised. Other plants, fitted for special environments, had a more limited distribution, examples being the manioc of the humid lowlands of the Amazon basin and of the West Indies, and the common potato that was cultivated most extensively in the rather arid highlands of Peru. Wild stocks for some of the aboriginal food plants of America are often difficult to obtain, but botanical knowledge is far from complete for the more significant regions.

The cradle of New World agriculture appears to have been the highlands of Mexico and Central America. The nearest wild relative of maize so far discovered is a grass called in the Aztec tongue *teocentli* (sacred maize). When we consider the geographical and climatic range of maize, we must admit that the Mexican plateau is an intermediate and very likely home for the wild ancestor of this great food plant. On the north its cultivation had been extended in pre-Columbian times to the mouth of the St. Lawrence, and on the south to the mouth of the Rio de la Plata. It had been modified by careful breeding to meet extreme conditions of heat and cold, drought and moisture.

In restoring the early history of agriculture the most important source of information is archæological rather than botanical. There are manufactured objects, such as pottery vessels, associated with agriculture or dependent in a general way upon it, and some of these are practically indestructible; whereas plants and seeds survive only under the most exceptional conditions. Earthen bowls are both heavy and fragile and consequently of little use to wandering peoples. Stationary peoples alone develop pottery, and such peoples are usually on the agricultural plane of life. In America we find that the boundaries of pottery distribution closely parallel the boundaries of agriculture distribution, extending in some regions slightly beyond them. Pottery is made with an infinite variation in form and ornament and has almost the historical value of a written document. Like agriculture, pottery making was independently invented in the New World, along with loom weaving and other high arts, and probably spread outward from a single point of origin.

In the valley of Mexico pottery remains of sharply differing styles have been found in layers one above the other, and it is clear that the lowest layer is historically the earliest. The pottery of this lowest layer shows peculiar features in construction and ornament, and it has been possible to prove by these special features that ceramic art spread from Central America across northern South America to the mouth of the Amazon, and over the mountains of Colombia and Ecuador to the coast of Peru. All the higher civilizations in the New World seem to have risen from the general level of what has been called the "archaic horizon." The trail of pottery of the ancient type marks the first distribution of agriculture.

When we examine the exact distribution of this most ancient of all pottery, we find that it is abundant in open, arid country, and rare or wanting in humid, forested country. Theoretically, agriculture would be more likely to originate under conditions that were hard rather than under those that were easy. Necessity, they say, is the mother of invention.

Irrigation is often looked upon as a remarkable sequel to the introduction of agriculture into an arid country. But from the best historical evidence at our command, we should rather regard it as an invention which accounts for the very origin of agriculture itself. The earliest records of cultivated plants are found in Mesopotamia, Egypt, Mexico, and Peru, where irrigation was practised, and in each region are likewise found the earliest developments of the characteristic arts of sedentary peoples—namely, pottery and weaving, and the elaborate social and religious structures that result from a sure food supply and a reasonable amount of leisure.

Quite aside from these known facts in the case, there are several reasons why we should expect to find the first appearance of agriculture in an arid environment. The press of population on food supply is greater there than in the free-and-easy lands where nature is bountiful but where an insidious competition works behind the screen of plenty and cuts down life. In the desert the clearing of the field is less laborious than in the jungle, and the control of the life-giving water makes man the master of the entire situation. As for the intermediate type of environment, where agriculture is possible without irrigation, and where it normally spreads with the rise of human culture, there is usually such a supply of wild game, of berries, and of edible roots, that the advantage of tilling the soil does not at first appear. Even when agriculture is known in such favorable country, the indigenous plants are seldom found under cultivation.[1]

It is perhaps an open question whether the extreme tendency to conserve energy, seen in most desert plants, has not increased their comparative food value over plants of more propitious climes. At any rate, seeds that grow with avidity on the slightest encouragement form a large part of the dietary of desert peoples. The screening and washing of these seeds at springs and beside streams would naturally result in volunteer crops and suggest artificial watering. Whether the release of these wild plants from a harsh life to one of continuous ease under irrigation would result in physical changes greatly increasing their food value is a question that botanists should answer. Certainly after the plant has been reduced to cultivation, the adaptation to new environments must be tremendously hastened by artificial selection. Only the plants that grow to maturity give seeds for the next planting, and these seeds are carefully preserved and planted in the most favorable situations.

Agriculture received special emphasis in Mexico and Peru. Maize, beans, and squashes are common to both areas, but with considerable local variation. Sweet potatoes, the *camote* of the Aztecs, are also cultivated in both Mexico and Peru, but are probably of humid lowland origin. In Mexico several varieties of red peppers, often called by the Aztec word *chile*, were cultivated, as well as the tomato called *tomatl* in the same language. The latter was

Pottery reproduction of maize, cast in molds that were made over actual ears of maize, have much scientific value. These reproductions were sometimes used as details on great ceremonial urns in southern Mexico

The "maize god" of the Peruvians (left) was buried in the field as a prayer for good crops, and in some sections the ceremony is still kept up. The body is formed of molded ears of maize.
The cemetery of Chimbote on the arid coast of Peru has furnished us this jar decorated with peanuts (water jar at right). The realism of these ancient casts made from molds is in contrast with the rather conventional treatment of modeled representations

*From *Amer. Mus. Jour.*, New York.

[1]The abundant harvests of wild acorns in California, of wokas in southern Oregon, of wappato along the Columbia, of camas and kous in the pleasant uplands of Idaho, and of wild rice in the lake regions of Minnesota and southern Canada, were effectual barriers against the invention or spread of agriculture among the tribes inhabiting these regions.

POTTERY REPRODUCTIONS OF SQUASHES

Peruvian collections give us many examples of molded and modeled squashes (see the last two specimens), showing the special breeds developed in that region. The very texture of the rind is minutely reproduced in some pieces.

Gourds, squashes and pumpkins were cultivated by the ancient Mound Builders of the eastern United States (see first specimen). Representative art never attained to the skill that is exhibited in Peruvian pottery, nevertheless the intention is unmistakable.

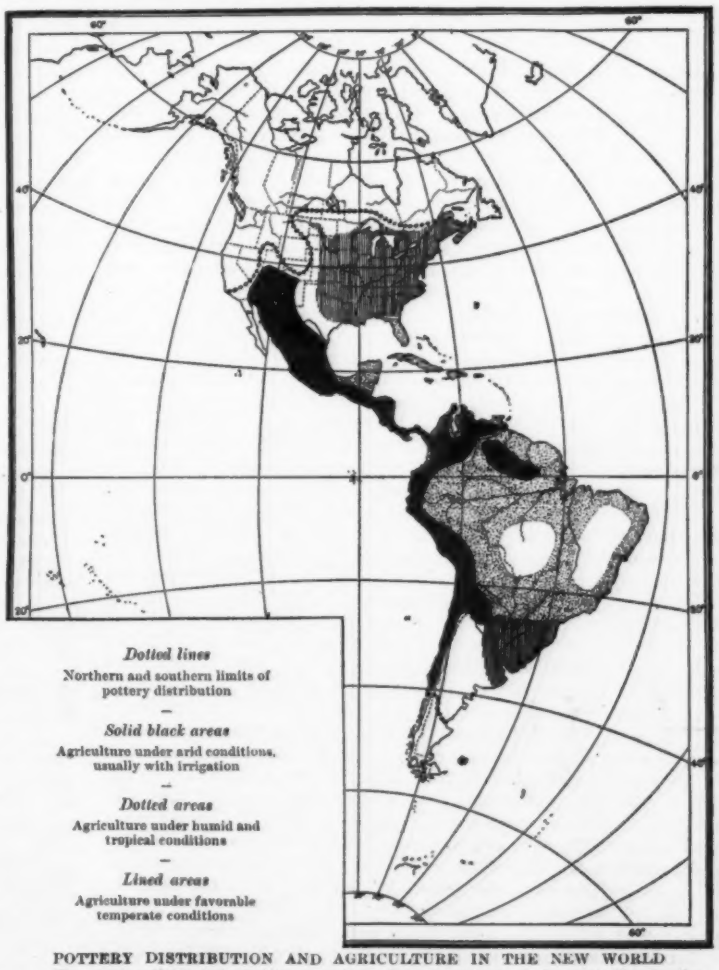
used mostly in softening the rigors of chile sauce, and several varieties are described in early books. Cacao takes its mispronounced name from the Aztec word *cacouatl*, which referred to the dried nibs. When ground, this fruit seed was called *chocolatl* and was made into a delicious drink. Cacao was grown in the lower and more humid parts of Mexico and Central America, under the shade of another tree, called the "mother of cacao," and was an object of trade with the highland tribes. This plant does not seem to have been known to Peru, although the mountain tribes of western Venezuela cultivated it and made a drink called *chorate* from the seeds. Cacao was grown also in many parts of the lowlands of South America and in the West Indies.

In Peru the potato was especially developed. It is doubtful if this plant was known to the Mexicans, although it was commonly grown throughout the Andean region, and a wild form occurs as far north as Colorado. Peanuts also appear to be a Peruvian specialty.[2]

The weight of anthropological science is strongly against over-sea transmission as an easy explanation of enigmas in human culture, and it behooves us not to assume lightly that any cultivated plant was common to both the Old World and the New before the coming of Columbus, until the fact has been established beyond doubt. Domestic species of plants in cosmopolitan use in 1500 are rare, and possibly the only example is the common gourd, which appears to be one and the same in the Old World, in the islands of the Pacific, and in America. It is not a food plant, but was much cultivated for household and ceremonial uses. An important economic plant, that does not appear as a single species but rather as a world-encircling family of closely related species, is cotton. Many wild species have never been brought under cultivation or turned to human use. Cotton also occurs on oceanic islands, such as the Galapagos, which were entirely uninhabited until modern times. But it is important to note that the modern cotton of commerce is essentially that of the American Indians.

Both the gourd and the cotton are enabled by nature to take the widest advantage of distribution by wind and water, and we may be permitted to assume that they passed in such fashion from the Old World to the New. The coconut, which was doubtless known in the Old World before the discovery of America, may have been distributed by ocean currents. Nearly all the related palms are indigenous to tropical America, but there is no certain evidence that the coconut itself actually existed under cultivation, or even in a wild state, in pre-Columbian America. No remains of the fruit and no pictures of the tree are found in archæological collections, and native names for the coconut are conspicuously absent among Indian tribes.

The earliest references to maize in China are considerably subsequent to the discovery and conquest of America, and while the evidence points to Tibet as the region from which maize entered China, we must remember that the caravan trade between the Near and the Far East was at its height in 1500. Moreover, the world empire of Spain embraced large sections of the East Indies as well as of the West Indies and the mainland of America. It was an age that throbbed with energy, when new ideas were eagerly seized upon. The exchange of occidental and oriental food plants is seen not only in the introduction of maize and sweet potatoes into China, but also in the introduction of the banana and sugar-cane into America.



POTTERY DISTRIBUTION AND AGRICULTURE IN THE NEW WORLD

The most reliable information regarding the agriculture of the past lies in the pottery (fortunately indestructible through the centuries) which was inseparably associated with it. The oldest type of agriculture (black on the map) appears to have arisen in arid country of high altitude, where irrigation was necessary, extending finally from southern Colorado and Utah to southern Chile.

The second type (dotted on the map) developed in humid and heavily forested tropical lowlands, where the land had to be cleared before planting. The brilliant Maya civilization was founded on an agricultural conquest of the rich lowlands of Central America.

The third type developed in temperate country, partly open and partly forested, and was best represented in the eastern part of the United States. Maize, beans and squashes were common products of all three types of agriculture.

The map given herewith shows the limits of pottery distribution and, within these limits, the areas known to have been given over to agriculture. A rough distinction is made between three general types of agriculture. The first, and apparently oldest, type occurs in open and rather arid territory of considerable elevation, where irrigation is usually necessary. The second type is found in the humid, tropical lowlands where the land must ordinarily be cleared of the forest before planting can be done. The third type occurs under temperate conditions in partly open and partly forested country where irrigation is not required. The arid highland area etxends from southern Colorado and Utah to southern Chile. An outlying area is also drawn across the Guiana highlands, but this is somewhat doubtful and proof of its existence must await future exploration. As we have already seen, agriculture seems to have spread over most of this open country on the first wave.

The second type of agriculture is that developed to meet the conditions of the humid and heavily forested tropics. The Maya civilization, probably the most brilliant of the New World, was made possible by the agricultural conquest of the rich lowlands of Central America. On the highlands the preparation of the soil is comparatively easy, owing to scanty vegetation and a control vested in irrigation. On the lowlands, however, great trees have to be felled and fast-growing bushes kept down by untiring energy. But when nature is truly tamed, she returns recompense manifold to the daring farmers. Moreover, there is reason to believe that the removal of the forest-cover over large areas affects favorably the conditions of human life, which under a canopy of leaves are hard indeed.

But while extremely high civilization might result when the material wealth of the humid tropics is garnered by a closely organized people, the general run of more or less haphazard agriculture in the tropics leads to no such state of affairs.

(*Continued on page 127*)

[2] There was also a sort of fruit called by the Aztecs *tlalcacauatl* (earth cacao), which is said to have been roasted before eating. This fruit may possibly be identified with the peanut, since the modern Mexican word for peanut is *cacahuate*. In South America the Peruvian word *mani* is used. Several wild species of peanuts are said to occur in South America. Other Peruvian and Colombian products are the roots of the oca, and the arracacha. Great use was also made in Peru of the seeds of quinoa, a plant of the pigweed family, and in Mexico small seeds of similar type were used.

Specific Nutritive Values

German Experience Which Goes to Show the Indispensable Nature of Butter or a Real Equivalent

For many years it has been supposed that while a certain amount of albumen in the food was indispensable for the purpose of body building the carbohydrates including the fat, starches and sugars were practically interchangeable, their function being the provision of heat and energy. The shortage of fat in Germany due to its diversion to the making of nitroglycerine has naturally caused a painful interest in the subject, all the keener because there was likewise a shortage of sugar. Dr. Hans Aron of the Children's Clinic of the University of Breslau has published the results of some remarkable experiments with regard to the nutritive value of fats and oils which seem to prove conclusively that a minimum quantity of fatty matter is irreplaceable by any other food substance, being required for the maintenance of the organic structure in a state of health, and being, therefore, as indispensable as the minimum mount of protein which is likewise required. Moreover, he has discovered that not all fats and oils possess an equal amount of vital value. Best of all is butter fat, which can be replaced, however, either by the fatty substance found in the yolk of eggs, or by cod liver oil. Strange to say most other oils including those of such high food value as olive oil and almond oil are lacking in the essential property to which we have given the term "the vital value." He also concludes that minimum amounts of the carbohydrates, the mineral salts and the extractive matters of vegetable and animal origin are irreplaceable. We take from a late number of the Biochemische Zeitschrift (Berlin) the following account of the valuable conclusions led to by his experiments upon animals:

The question as to the definite nutritive value of various foods is of the greatest importance both in theory and in practice. Many authorities regard the caloric value of an aliment as the fundamental measure of its worth. Thus we read in Koenig's basic work[1] "by nutritive value is meant the total amount of nutrition units contained in any aliment . . . to measure the alimentary value of a food we need regard only the three food groups, of nitrogenous substances, fats, and carbohydrates. But as Hoeber[2] has pointed out this identification of nutritive value with the number of calories, which is frequently repeated in the literature of the subject, fails to state the entire truth. . . . Other authorities have sought to come nearer to the heart of the matter by estimating the "utilizable nutritive value" i. e. that portion of the albumen taken into the system and of the total amount of calories which the body is actually capable of turning to use. But even if we substitute "physiological nutritive value" for crude food value the matter always resolves itself into the question of the degree in which the given aliment is able to satisfy the body's need of albumen and of heat. It has been the accepted view that the "nutritive value" of a given food can be estimated with sufficient closeness by determining the utilizable albumen on the one hand, and the utilizable calories on the other[3] . . . so that the study of nutrition has developed into an almost mathematical science of calculation which has sought to solve by means of figures not only theoretic problems, but also the great questions involved in the feeding of the populace.

This form of calculation as to food values is indeed extremely simple and useful for certain practical purposes, but in many cases a mathematical knowledge of the number of calories and the quantity of albumens fails to give us a sufficiently complete idea of the real nutritive "value" of a food.

It has long been understood that a certain amount of albumen was irreplaceable by any other sort of food because of its peculiar function with respect to cell structure, but the fats and carbohydrates being regarded as mere storehouses of heat and energy it was supposed that fat could be entirely replaced by other food stuff furnishing an equal amount of calories. For this reason it has been customary in estimating the nutritive value of any food to determine the percentage of albumen and the total number of calories yielded, it being regarded as a matter of indifference which of the three food groups furnished the said fuel. In this manner the idea has grown up that fat, as such, can be entirely dispensed with in the diet provided there is a sufficient quantity of other food stuffs to take its place.[4]

So far as the body's needs of heat and energy are concerned it has, in fact, been proved beyond a doubt that all three food groups are isodynamic and that, therefore, the carbohydrates are entirely capable of taking the place of fats. But this fact in no way justifies the conclusion which is generally jumped to that fat can be replaced by the carbohydrates in all its functions. . . . The present conditions with regard to food supplies render it a question of the greatest interest and much practical significance to determine whether fat can be entirely excluded from the diet without causing injury to the organism. Certain experiments of mine have led me to conclude that the common idea of the dispensable nature of fats is entirely wrong. I base my opinion upon researches carried on from 1912 to 1914 to whose results I have referred elsewhere,[5] but which it has not heretofore been possible to publish, because of outside reasons. In my experiments concerning the influence exerted upon growth by nutrition I was frequently struck by the fact that young growing rats fed upon a mixture of casein, bran and starch, after thriving for a comparatively long time began to grow sickly and finally perished unless the diet was changed, while other animals fed upon a similar mixture which, however, contained a certain percentage of butter, remained in much better condition. In order to see whether the butter was really responsible for this better condition, as it appeared to be, I prepared two mixtures of food; the first of these consisted of 120 grams of plasmon, 100 grams of wheat bran and 800 grams of wheat starch while the second contained the same elements in the same proportion but with an addition of 25 grams of butter.

In the first experiment three rats from the same litter (Nos. 84, 85, 86) were fed with the butterless food mixture, beginning about the 25th day of their age, while two other control animals (148, 161) were fed with the second mixture. The curves on the diagrams 1 to 5 in which the hollow circles and dotted lines indicates nutrition with the butterless mixture, while the solid circles and lines indicate feeding with the second mixture, make it very evident that the three animals which lacked butter in their food (curves 1 to 3) after thriving very well at the beginning began to lose weight when about 120 days old and finally died between the 150th and 160th day of their age. The two other weight curves (Nos. 4 and 5) show on the other hand a continuous state of health and development in the two animals whose food contained butter. Both these remained under observation for 210 and 250 days respectively, during which time they remained strong and healthy. Although this experiment was quite convincing others of the same sort were repeated.

In four series of experiments two animals of like sex from the same litter were first fed for a certain period of time with the food mixture containing butter, after which one of them continued this diet while the other was transferred to the butterless mixture. In the first experiment (curve 6) two male animals (104 and 107) were fed with the mixture containing butter from the 25th to the 162nd day of their age and after they were approximately fully grown the animal 107, which weighed 220 grams, was fed upon the butterless mixture, while No. 104 continued upon the original diet. Upon the 250th day of their age, i. e. after 85 days of the butterless feeding No. 107 died, while 104 remained under observation till 286 days of age during all of which time it remained in excellent condition.

The next series (curve 7) was carried out with two females of the same litter (Nos. 105, 106) and produced similar results except that in this case the animal 105 died 35 days after being changed to the butterless mixture, while the sister animal remained perfectly healthy during the ninety days further during which she was observed. The third series (curve 8) was carried out with two males from another litter (123 and 126); the stronger animal 123, which weighed 170 grams when 120 days old, was transferred to the butterless diet at that time while its brother No. 126, which weighed 158 grams at the same age, continued to be fed upon the mixture containing butter. In this case No. 123 continued to thrive fairly well for 80 days longer though not so well as its butter fed brother No. 126, but at the end of this time there was a rather abrupt loss of weight and at the end of the 84th day No. 123 died while his brother No. 126 flourished normally on the diet containing butter as long as observed, namley, till 275 days old. The fourth experiment (curve 9) carried out with two female animals Nos. 133 and 134, was closely analagous in its results. . . . A study of these experiments gives convincing proof that the addition of butter to the food supplied is of eminent importance. All of the seven animals who were deprived of butter died sooner or later while at the same time the 6 control animals who were fed on exactly the same mixture with the xeception of an addition of 2.5 per cent. of butter continued to grow and develop in good condition. The age of the animals was of no essential importance. Not only the young animals which were put upon the butterless diet shortly after being weaned, but also the grown animals who were not put upon this diet until three or four months old, continued to thrive quite well for a certain length of time. The harmful effects of the butterless diet first showed itself in all the animals after a comparatively long time and in the younger animals there was a lapse of nearly three months before it could be recognized by their aspect that the butterless diet was insufficient. It is important to note, therefore, that if the experiments had continued a shorter time, being interrupted after the lapse of 50 days or even in many examples after 100 days, the injurious effect of the lack of butter would have failed to be recognized.

The objection may be raised that in the composition of the two food mixtures no attempt was made to substitute for the butter another food stuff containing an equal number of calories. But this point is of no importance since the animals were not restricted in the amount of food eaten but always had as much as they would take, so that the cages constantly held an excess of food. On the contrary, the animals fed upon the butterless mixture received in fact a slightly greater percentage of albumen and bran than the others. Both grups of animals in fact received an amount of albumen, mineral salts, and total calories in excess of what they would eat. The only difference in the two mixtures consisted in the fact that one of them contained 2.5 per cent of the dry substance, butter fat. Hence these experiments furnish convincing proof that a certain amount of butter in the food supply under the given conditions is absolutely indispensable, not only for young growing rats but also for the mature animals.

This indispensability of butter fat can have no connection with its function of furnishing heat, for as we know fat as a combustible is readily replaceable by other food stuffs. The conclusion is forced upon us that the organism requires indispensably a certain percentage of this kind of nutritive fat as such, exactly as in the same manner as it requires for construction purposes certain elements of the albumen molecule, not on account of their combustible value but as building stones so to speak. It is extremely likely that it is not the fats, using the word in the strictest chemical sense i. e. definite glycerine ester fatty acids, but other materials which are contained in the nutritive fat and which are here of decisive importance. Extensive investigations by Stepp[6] indicate that substances which we class among the lipoids are essential and the indispensable elements of nutrition in the long run. It is indicated further in new researches by the American investigators, Osborne and Mendel[7] and McCallum and Davis[8] that the various natural food fats contain different amounts of these vitally important lipoids. Experiments made during the last few years by the above named scientists indicate that butter cannot be replaced by all kinds of fats. Animals fed for a long time upon artificial food mixtures in which the only nutritive fat was lard, olive oil, or almond oil, suffered almost as much in the long run as those whose food contained no fats whatever. On the other hand cod liver oil and the fat in the yolk of eggs were found to be comparable to butter in their effects; according to recently published investigations by Langstein and Edelstein[9] Palmin [sic] and margerine are less valuable nutritive fats than rapeseed oil (often called colza oil). The experiments described above were carried out with only a single kind of animal and it would, of course, be desirable to know whether its results can be accepted as applying to animals in gen-

[1] I. Koenig, The Chemistry of Human Foodstuffs and Condiments (in German).
[2] R. Hoeber, Biochem. Zts., 82, pp. 68 to 71.
[3] N. Zuntz, Nutrition and foods, Leipzig, Berlin, 1918 (in German).
[4] N. Zuntz, *loc. cit.*
[5] Aron, Berl. klin. Wochenschr. (Berlin Clinical Weekly), 1914, pp. 972 to 977.
[6] W. Stepp, Zgs. f. Biol. (Journal of Biology), 57, p. 135; 59, p. 366; 62, p. 405; 66, pp. 339 and 365.
[7] Th. B. Osborne and L. B. Mendel, Journa of Biological Chemistry, 12, p. 81; 15, p. 167; 16, p. 423; 17, p. 401; 20, p. 379; 24, p. 37.
[8] E. V. McCallum and M. Davis, Journal of Biological Chemistry, 14, p. 401; 15, p. 167; 19, p. 245; 20, p. 641; 21, p. 179.
[9] L. Langstein and F. Edelstein, Zts. f. Kinderkrankh. (Journal of Children's Diseases), 16, p. 305; 17, p. 255.

eral and to man in particular. However, my experiments have convinced me that it would not only be inadvisable but highly dangerous to place human beings on a diet entirely lacking in fat for a long period of time. I am strengthened in this opinion by my clinical observations of unweaned infants and young children whose bodily condition never fails to reveal the great importance of fat in the diet and the advantage of foods rich in fat over those which are poor in fat."[9] On the whole we are justified in believing that the conclusions formed are general in their application to other animals and to me. There are in fact many other basic principles in the science of nutrition which we accept as entirely applicable to human beings although our knowledge of them has been gained by experiments on the lower animals. The effects of the addition of fat to the diet in my experiments were so striking that no doubt can remain as to the decisive significance of this quantity of fat.

Thus we are led to the conviction that in the estimation of the "nutritive value" of a food the nutritive fat must be regarded as analogous to the nutritive albumen; for the former like the latter has certain specific functions to fulfil in which it cannot be replaced by other nutritive substances. In both groups we must distinguish, therefore, between the combustion value or number of calories found in all organic foodstuffs and what may be called the "specific nutritive value." This specific nutritive value (Sondernährwert) of a foodstuff is connected with the characteristic properties of the said foodstuff; it is the expression of the specific function which can be exercised only by the food stuff in question and which, therefore, in contrast to the operation of the combustion value is incapable of being replaced by other nutritive substances.

The specific nutritive value of nutritive albumen corresponds to the "albumen value" and is based upon the contents in amino-acids; the specific nutritive value of nutritive fat appears to be connected with the presence of certain lipoids.

Since the various nutritive fats found in nature are built up in the most various manner from a combination of strictly chemical fats together with lipoids and other accessory constituents of fats, the specific nutritive value of the different kinds of fat differs very widely. For this reason also the smallest quantity of fat required to maintain health or even life, likewise differs widely according to the nature of any given nutritive fat. Here again the case is completely analogous to that of albumen. The minimum amount of albumen required in our diet varies according to the nature and the origin of the nutritive albumen concerned. Albuminous bodies are more or less valuable biologically according to the construction of the albuminous body in question out of the various amino-acids. A very small quantity of those albumens having a high biological value (those of animal origin) satisfies the body's need of albuminous bodies while a larger amount is required in the case of albuminous bodies having a lesser biological value (mostly those of vegetable origin). In precisely a similar manner we can speak of the different kinds of fats as having a higher or a lower degree of biological value. The biological value of the fats appears to be dependent upon the content in lipoids.

When certain indispensable amino-acids are lacking in albuminous bodies, as is the case, for example, in glue and in horn then the organism cannot survive with this form of albumen alone but perishes in the long run no matter how large the quantity provided of the inferior albumen. Such albuminous bodies we designate as incomplete. In corresponding wise there appear to exist incomplete nutritive fats, those namely which lack certain indispensable constituents. Certain organic fats including butter fat, cod liver oil and egg yolk fat are of high biological value for young growing rats and may be regarded as complete fats, while lard, olive oil, almond oil, palmin [palmin is in dictionary, but I rather think palm oil is meant] and margerine must be regarded as being incomplete kinds of fat and of lower biological value. To avoid misunderstanding, however, let me repeat that this division into complete, less valuable, and incomplete kinds of fat is entirely inapplicable to fats with regard to their combustible properties, since for this function only the value of the calories is decisive, just as the constitution of albumens i. e. the nature of the amino-acids they contain is of no importance as regards their combustion value.

It may be stated as a law that henceforward in considering the nutritive value of any food we shall have to take into consideration the body's definite need of a minimum amount of fat just as at present its minimum need of albumen is considered. . . . It is naturally not possible as yet to state this minimum in exact figures, but it can be said with great probability that this minimum varies greatly with respect to the various kinds of fats.

Possibly the conditions of food supply at the present moment give peculiarly favorable opportunities for extensive observation as to the smallest amount to which the percentage of fat in the diet can be reduced without injury, as well as which kinds of fat have a high biological value and which a lower value for human beings. But the animal experiments described remind us forcibly not to underrate the value of a small amount of fat and especially of butter fat in the diet. And we must not underestimate the vital importance *of the question as to what fraction of the calories contained in our daily ration should consist of fat and of butter fat in particular.* It has been a too common error hitherto to consider it quite unimportant as to whether the individual received from five to ten grams of butter in his daily ration or whether this was replaced by an equivalent number of calories of carbohydrates. Indeed the question at once arises as to whether it would not be advisable to divert a portion of the carbohydrates designed for human food to the purpose of feeding milch cows in order to increase the quota of butter or milk in human diet, even when this roundabout method involves a loss of calories as has been demonstrated.[11] It is quite possible that such a small sacrifice of combustible material might yield a very essential and important augmentation of the nutritive value of the daily ration, just as we found the immense superiority of the diet containing 2.5 per cent. of butter. We should be careful, however, in deciding this question not to estimate nutritive value merely according to the number of calories, thus regarding that food as the richest which has the highest combustion value but must take into consideration also the specific nutritive value and must not fail to give proper weight to the amount and nature of the fat content.

We now come to the third group of foodstuffs that contain the carbohydrates and we shall attempt to show that there is an analogous necessity for a minimum mount of these in the diet. These constituents of our diet likewise possess a specific nutritive value besides their combustion value and for this reason they are in the long run indispensable elements of our food. The carnivorous animals, of course, such as the dog and beasts of prey, are able to live for long periods exclusively upon flesh, their diet, therefore, consisting practically of albumen and fat with very small quantities of glycogen. But this is not true of the omnivorous animals in which we must include man. When man is fed upon substances which are extremely poor in carbohydrates abnormal products of metabolism [Stoffwechselproukte] soon make their appearance, and if such a diet be continued longer it must be regarded as injurious because of the intensive degree of putrefaction in the intestines occasioned. However, the question as to the minimum amount of carbohydrates required in the diet plays a subordinate part so far as concerns the diet of adults. As a usual thing such a minimum is abundantly provided, especially when albumen and fat are so scantily provided as in the present condition of our food supply. But the case is far otherwise with infants. It has long been known tnat the comparative proportion of the elements in the infant's food, what has been called "the correlation of the various nutritive substances"[13] may be of decisive importance. Alterations in the correlation of the nutritive elements suitable for an infant may lead under certain conditions to disturbances which have received the designation of "nutrition disturbances ex correlatione."[14]

It is of peculiar interest in this connection to note that the percentage of carbohydrates in the diet as constantly shown in clinical observations of infants and young children cannot be lowered below a certain limit without disturbance. When infants are given an artificial food made richer with albumen and fat, but poor in carbohydrates ("albumen milk" without the addition of sugar), they generally fail to thrive in spite of the large amount of calories provided by such food.[15] But if a portion of the fat and the albumen is replaced by carbohydrates there is usually a sharp rise in the weight curve, even with a considerably smaller amunt of calories in the diet. This and many similar observations with regard to the nutrition of infants teach us that a certain minimum and a not inconsiderable quantity of carbohydrates is required to obtain increase of weight. Carbohydrates cannot be replaced by the other food groups (fats, albumen) with respect to this requisite of growth in the young individual. We must, therefore, attribute a specific nutritive value to the carbohydrates also, at least, so far as bodily growth is concerned and regard a minimum percentage as an indispensable element in the diet of the young growing child.

* * *

According to the prevailing view the three food groups thus far considered comprise all the substances necessary to consider as having "nutritive value." But as I have attempted to demonstrate in experimental and clinical researches (l. c.) it is possible for extractive matters [Extraktstoffe] also to play an important part in nutrition.

In this place I must confine myself to repeating a few experiments in order to show the striking amount of nutritive value which vegetable extractive matters may possess, referring readers to my previous article for details.[16]

This experiment was likewise carried out with young growing rats. All the animals were fed with the same mixture consisting of 1,000 gramms of wheat starch, 125 gr. of plasmon, 100 gr. of cellulose, 50 gr. of butter and 1 gr. of a mixture of salts. This mixture contained albumen fat and carbohydrates which had been proved suitable for rats, a sufficient amount of mineral matter was carefully provided in it, and the demands of appetite were met by the addition of cellulose (ash-free filter paper). Young rats fed upon this failed to thrive and gained but little in weight, though so plentifully supplied that an excess of food was always present in the cage. But when the animals were given small doses daily of an extract of wheat bran besides their other food, they promptly gained in weight and developed admirably. In the curves 10 to 12 the hollow circles represent the feeding without the addition of the extract and the solid circle the feeding with this addition. In numerous other series of experiments these results were strikingly confirmed, even when the extractive matters came from other plants, e. g. barley (malt). These experiments definitely prove the decisive importance in nutrition which may be exerted by extractive matters even when there is an abundance of the other necessary food elements. It remains only to inquire into the nature of their nutritive value. In order to obtain the abrupt gain in weight which is to be observed in curves 10 to 12 (solid circles) from 80 to 100 millegramms of the prepared extract were required, quantities whose combustion value is utterly insignificant as compared with that of the rest of the food. The effects of the extracts can be explained only upon the assumption that they fulfil certain functions in which other nutritive matters are unable to replace them. Plant extractive matters, therefore, explicitly possess what we have termed specific nutritive values. But while albumen and fat also play a part as combustibles, the quantities of vegetable extractive matters required in the diet are so small that their caloric value can be ignored. Hence we may say that the nutritive value of such extracts resides almost exclusively in their specific nutritive value.

The researches with regard to the origin of scurvy, beri-beri and similar diseases, clinical observations upon infants and young children both teach us that fresh vegetables are important elements of the diet of man,[17] and as we now see their specific nutritive value depends upon their content in extractive matters. Obviously, therefore, practical experience fully coincides with the results of my experiment upon animals namely that a form of nutriment in which such extractive matters are lacking provides an insufficient for human beings. . . . Such a diet may lead to serious disturbances in health and even to death.

For this reason in order to estimate the nutritive value of fruits and various kinds of vegetables we must take into account the fact that the value of such foods resides not so much in their percentages of albumen fats or carbohydrates as in their richness in extractive matters.

When Pirquet[17] in his "System of Nutrition" estimated the nutritive value of fruits and vegetables from the number of calories contained in their dried substance his conclusions were necessarily incorrect, especially for children.

(*Continued on page 127*)

[9] H. Aron, Berl. klim. Wochenschr. (Berlin Clinical Weekly), 1918, p. 546.

[11] Paul Eltzbacher and collaborator, The Feeding of the German Nation and the English Starvation Plan (in German). Brunswick, 1914.

[13] L. Langstein, Festschrift of the Kaiserin Augusta Victoria House, 1909, p. 72.

[14] G. Bessau, Monatschr. f. Kinderheilk. (Monthly of Children's Diseases), 13, p. 431.

[15] H. Finkelstein, Textbook of Infants' Diseases (in German), 3. Berlin, 1912.

[16] H. Aron, Monatschr. f. Kinderheilk (Monthly of Children's Diseases), p. 359.

[17] Wilhelm Stepp, Ergebnisse d. inn. Med. u. Kinderheilk 15, pp. 258 to 364. H. Aron, Berl. klim. Wochenschr. (Berlin Clinical Weekly), 1918, p. 546.

[17] Pirquet, Ztschr. f. Kinderheilk (Journal of Children's Diseases) 14 to 18.

Effect of Fog on Light Intensity*

Relative Intensities of Different Colored Lights in Fog

By C. L. Utterback, Physical Laboratory, University of Washington

IT is the purpose of this investigation to study the transmission of lights of different wave lengths through a fog.

A quantitative determination of the density of the fog was not attempted, but care was taken to reproduce as nearly as possible the conditions upon which the density of the fog depends. In all instances a sufficient number of fogs was produced so that the average of the readings for the different wave lengths represent the effect of a fog of nearly constant density.

Measurements were made on thick, medium and slight fogs, but the data given here is for the medium fog only. What is here called a medium fog is about the density of our moderate fog.

APPARATUS.

In order to compensate for the small absorption of light it was necessary to use a long tube filled with the fog. The apparatus is shown in diagram in Fig. 1. It consists of an air-tight, asbestos-covered tube, *A*, of galvanized iron, 190.5 cm. in length and 16 cm. in diameter. In the middle of its length was a box *M* of the same material 40 cm. square. The source of light was a 6-8 volt, 21-candle-power automobile lamp, *B*. The light was made nearly parallel by a condensing lens at *C*. In front of this lens was located an adjustable circular opening, *D*, by means of which the size of the beam of light was regulated. The beam was passed through the tube and allowed to fall on the illuminometer plate, *E*, where its intensity was measured by means of a Macbeth Illuminometer. The ends of the tubes were closed by glass plates and were made as nearly parallel as possible. At *F*, small glass windows were placed in order that any scattering of the light might be observed. Thermometers were placed at *G*. Glass tubes at *H* and *J* connected with the inside of the tube *A*. The one at *H* was used for the introduction of water. This was necessary in order to keep the air in the tube saturated with water vapor. The opening at *J* was connected by means of a T-tube to a mercury manometer and to the large glass jar *K*. This jar was connected to the air pump. Between the jar and the observation tube, *A*, was placed the ground glass valve, *L*, so that the air in the tube could be expanded very suddenly after the jar had been evacuated to any desired pressure. The inside of the tube was painted a dead black to prevent the reflection of any scattered light.

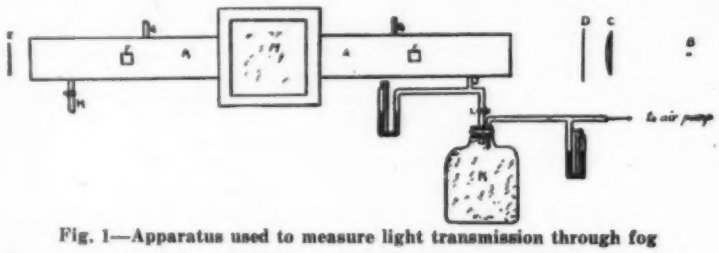


Fig. 1—Apparatus used to measure light transmission through fog

METHOD OF MAKING OBSERVATIONS.

The light was made to pass through the empty tube and its intensity in foot-candles at *E* was measured. The lamp was kept constant at 8 volts throughout the measurements. With the valve, *L*, closed, the pressure in the jar was reduced a known amount. Then by opening *L* the air in *A* was suddenly expanded and the resulting cooling produced the condensation of the water vapor. The intensity of the light at *E* was again measured.

It was found that by expanding the air in *A* to the same pressure, i. e., a reduction of 1.1 centimeters of mercury, and by keeping the space from which air was drawn into the tube each time well filled with dust particles, that a fog of practically the same density could be reproduced. The intensity of the white light transmitted through the fogs varied by less than one per cent. No other method for determining the density was attempted.

The different wave-length ranges were obtained by means of absorption screens.[1]

In some instances readings were taken on 6 fogs for one wave-length range, in others 10 readings, and in one case 20 readings. The number of readings depended on the intensity of the light under observation. The transmission bands of the screens were measured by means of a Hilger direct reading spectroscope, employing the diffraction grating. The lamp used in these determinations was the same one used for transmitting the light through the fogs.

The average temperature throughout the investigation was 19.5°C.

At no time was there enough scattered light to be detected at the windows *F*.

[The observed and calculated data are summarized in Table 1.—EDITOR.]

An accuracy in observation of approximately one per cent was obtained.

The last column of the table shows the intensity of illumination of different wave-lengths necessary to be delivered to the fog in order to produce on the plate *E* the same illumination as was produced from the uncolored light from the lamp, *i. e.*, 2.32 ft. candles.

Table 1—Summary of results of light transmission through fog.

Mean wave length	ILLUMINATION			
	No fog	Fog	Per cent transmit.	To deliver to fog to produce 2.52 ft.-c. at *E*.
	Ft.-candles	*Ft.-candles*		*Ft.-candles*
lamp	3.99	2.32	58.1	3.99
6331-Red	0.74	0.45	60.4	5.76
6190-Orange	0.71	0.44	62.5	5.56
6020-O.-Y.	0.08	0.07	84.8	4.10
5920-Yellow	2.02	1.76	87.1	3.99
5860- "	0.04	0.03	87.2	3.99
5570- "	0.86	0.75	87.0	4.00
5396-Green	0.24	0.21	87.3	3.97
5363 "	0.45	0.39	87.4	3.97
5240 "	0.34	0.29	85.2	4.08
4935-Blue	0.21	0.17	82.2	4.23
4605 "	0.05	0.03	71.9	4.84
Con-Auto.	0.39	0.30	79.7	4.36
West—Day.	3.22	1.90	59.0	5.90

Fig. 2—Curves of transmission through fog and through water. Note relative displacement toward violet of maximum transmission through water.

SUMMARY OF DATA.

From our data it appears that the transmission is highest for wave-lengths from about 5,300 to about 5,900 and falls off very rapidly toward the red but not so rapidly toward the violet. The difference between the maximum transmission obtained and the lowest transmission in the red is 31.0 per cent while this difference for the lowest transmission in the blue is 17.7 per cent.

A similar difference was found by Abbott[2] in the transmission of light through water vapor when there were dust particles in the air.

Investigations by Dr. T. Ewan[3] on the transmission of colored light through pure water gave results similar to those found in this study, as is indicated by Curves I and II.

Dr. Ewan's results agree with those obtained by Huffner and Albrecht.[4]

Curve I is the curve obtained for the transmission through fog. Curve II is the one obtained by Dr. Ewan for transmission through pure water. The maximum transmission through pure water is displaced toward the violet with respect to the maximum transmission through fog as found by the writer.

The mean wave-length for maximum transmission through fog is found to be about 5,620.

Wave-length 5,240 is not on the curve. The screen from which this light was taken had a slight transmission band in the red which had not been taken into account in determining the mean wave-length.

Curve I also shows that in order to have maximum transmission through fog, light must be composed of wave-lengths between the limits 5,300-5,900, and must not contain any red or blue, as is shown by the Conaphore lens and the Westinghouse Daylight glass.

CONCLUSION.

The data of this investigation shows that an automobile light, or any searchlight, will have the maximum transmission through fogs if the light is composed of wave-lengths from 5,300 to 5,900 only.

DISCUSSION.

T. D. Cope, Pennsylvania: It is of interest to compare the results of this investigation with the results of other investigations in the same field. In the *Proceedings of the Railway Signal Association*, 1905, page 291, in a paper on "The Roundel Problem," Dr. William Churchill of Corning, N. Y., states:

"The great absorption of light in an atmosphere laden with water vapor is a well-known fact. It is not so generally known, however, that some kinds of light penetrate a fog more effectively than others. Two years ago the German Lighthouse Board instituted a series of experiments to determine the relative percentages of absorption of waves at various points in the spectrum. A spectrum was projected through a box covered with glass at opposite ends and filled with steam condensed to fog by a cold water jacket. Photometric measurements proved that the greatest absorption occurred at the red end of the spectrum with a gradual decrease toward the violet end. Figuring the absorption at the *D* line as 100, the extreme red showed 108.7 per cent under the same conditions, the extreme violet 87.7 per cent. These figures are quoted from an unpublished report furnished to the writer through the courtesy of Geheimrat Koerter of the German Lighthouse Board. The results are of considerable interest since they prove conclusively that the tendency of all lights to shift in color toward the red end of the spectrum (the aspect of the sun or moon when just rising or setting being the best known illustration) is not due to the presence of water vapor. The effect of vapor is precisely the opposite.

"One other point which requires notice in this connection is that the light produced by a kerosene flame shows more penetrative power in a fog than some other kinds of artificial light. A striking illustration of this fact occurred a few years ago, when the German Government installed lights of 1,000,000 computed candlepower in an important lighthouse upon the island of Heligoland, superseding an oil light of 10,000 candlepower. The arc light proved of far shorter range in fog than the oil lamps and was accordingly soon discarded. It is true, the arc light shows a preponderance of blue rays which possess a higher penetration in water vapor than red or yellow, but for some reason not clearly understood, the waves emanating from the arc are all very feeble against a fog. Kerosene so far as fog is concerned, is a relatively satisfactory illuminant for signal purposes."

(Continued on page 128)

*Presented before Philadelphia Section of *Ill. Engin. Soc.*, and reprinted from their *Transactions*.

[1]Details about screens in original paper.—EDITOR.

[2]*Annals of the Astrophysical Observatory*, Washington, vol. 3, p. 214-218.

[3]*Proc. Royal Soc. of London*, 1894, vol. 57, 117-162.

[4]*Pogg. Ann.*, 1891, vol. 42, p. 1-17.

Experimental Wireless Telegraphy and Telephony—IV*

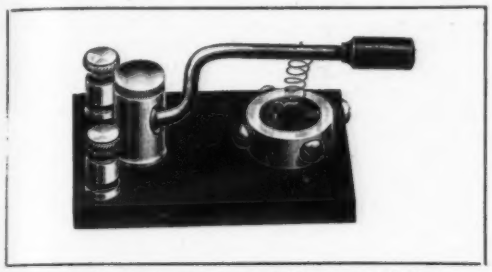
Crystal Detectors, Telephone Receivers, Receiving Coils and Condensers

By Louis Gerard Pacent and Austin C. Lescarboura

(Continued from Scientific American Supplement, August 9, 1919, No. 2275, Page 85)

CRYSTAL DETECTORS.

A very simple and convenient form of detector is obtained by the contact of two dissimilar solid substances properly chosen. The number of substances which have been found suitable for use in such detectors is large. This type of detector is inexpensive and easily portable, but requires frequent adjustment and is less sensitive than the average vacuum tube. For field sets where a compact and easily portable form of detector is required, the crystal detector is very



Typical detector of the rectifying crystal class, which is still widely employed

convenient. The use of crystal detectors is largely confined to such work now, and even in the portable military sets is rapidly giving way to the vacuum tube detector. For beginners, however, it represents the logical detector because of the simplicity of its attendant apparatus.

Among the combinations of solid substances which have been used as contact detectors may be mentioned silicon with steel, carbon with steel, and tellurium with aluminum. The most important contact detectors, however, consist of crystals, natural or artificial in contact with a metallic point. Examples of such minerals are galena, iron pyrites, molybdenite, bornite, chalcopyrite, carborundum, silicon, lenzite and zincite. The first three are, respectively, lead sulphide, iron sulphide, and molybdenum sulphide. Bornite and chalcopyrite are combinations of the sulphides of copper and iron. Carborundum is silicon carbide, formed in the electric furnace. The fused metallic silicon commonly used is also an electric furnace product. Zincite is a natural red oxide of zinc.

In order to test the sensitiveness of a detector at any time, a buzzer and battery are employed. The buzzer sets up oscillations which affect the receiving set the same as would the wireless waves.

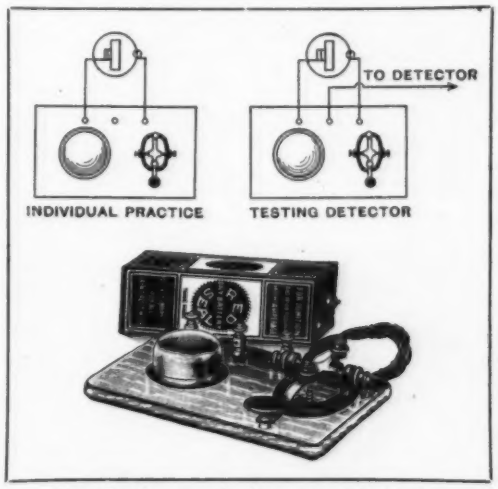
Probably the three most widely used crystals are galena, silicon and iron pyrites. Sensitive specimens of iron pyrites are more difficult to find than sensitive galena, but they usually retain their sensitiveness for a longer time than galena. These sensitive pyrite detectors are often sold under the trade name of "Ferron." The detector sold under the name of "Perikon" consists of a bornite point in contact with a mass of zincite. Another popular combination is silicon-antimony. Most crystal detectors operate without battery, particularly galena, silicon, and iron pyrites.

Various mechanical arrangements are used in different types of detectors. In the case of two dissimilar crystals, each crystal is held in a cup or jaw and brought in contact with its companion by spring pressure. Single crystal detectors use a sharp point which presses against the crystal by spring pressure, or a fine wire whose tip presses lightly on the crystal surface.

TELEPHONE RECEIVERS.

The distinctive features of telephone receivers for radio work are lightness of the moving parts and the employment of a great many turns of wire around the magnet poles. The lightness of the moving parts enables them to follow and respond to rapid pulsations of current. The large number of turns of wire causes a relatively large magnetic field to be produced by a feeble current. The combined effect is to give a very sensitive receiving device. Inasmuch as the size of wire used is always about the same (around A. W. G. No. 40 copper), the amount of wire and therefore the number of turns is usually specified indirectly by stating the number of ohms of resistance in the coils. Telephone receivers of fair sensitiveness for radio work have 1,000 ohms in each receiver (measured on direct current), while the better ones usually have 1,500 to 2,000 ohms per receiver.

The most common type, called the magnetic diaphragm type, has a U-shaped permanent magnet with soft iron poles, and a thin soft diaphragm very close to the poles so that it vibrates when the attraction is rapidly varied, producing sounds to correspond with the frequency of the pulsations of current.

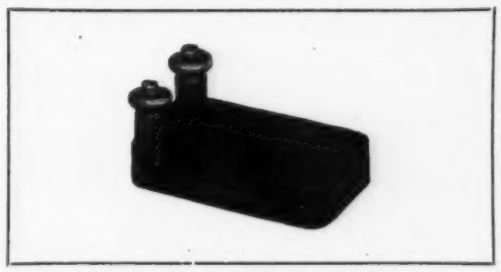


Combination practice buzzer and test set, with wiring diagram

The only other important type is called a mica diaphragm receiver. The regular diaphragm is of mica, and is put in the usual place in the receiver, but of course is not attracted upon directly by the magnets. Between the magnet poles a soft iron armature is pivoted, inside of a solenoidal telephone winding. It is arranged so that as it moves in response to changes of magnetism a small stiff wire attachment transmits the motion to the mica diaphragm. The armature is so arranged that there is no pull upon it at all, except when pulsations of current are passing through the coil. This is contrary to the ordinary magnetic telephone receiver where the magnet poles are always exerting a pull on the diaphragm. If there is no strain in the diaphragm between pulsations the vibratory movements due to incoming signals are much greater than if a strain were already existing in the diaphragm or armature. In the mica telephone this unrestrained vibration is communicated to the mica diaphragm near the ear.

RECEIVING COILS AND CONDENSERS.

The coils used in receiving apparatus are very simple, being usually wound in a single layer of wire on bakelite, pasteboard, or other insulating tube. The wire is usually stranded and covered with an insulation of



Typical fixed condenser used for receiving purposes

silk or cotton. In some types one or two sliders make contact with any desired turn of wire, the insulation being scraped off on top of the wires along a narrow path lengthwise of the coil. Some tuning coils make use of bare wire wound in such a fashion as to maintain an even space between turns.

Tuning coils, however, are fast passing out of date, except as equipment for the beginner in radio. Most sets today use no slider but have switches whose points are connected by tap wires to the turns of wire in the coil. One switch takes care of single turns, and the other switch makes contact to groups of, say, ten turns each. To cover 100 turns, for instance, one switch should have 9 points of ten turns each, and a zero point, making ten points in all, and the units switch should have 9 points and a zero point. Then any number from 0 to 100 turns could be used. If a coil had 400 turns the first switch in groups of 20 turns could have 20 points including zero, and the unit switch could also have 20 points for nineteen unit turns and zero.

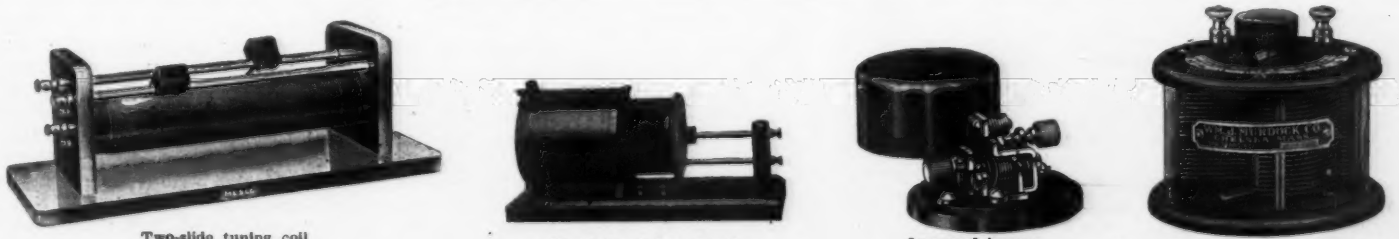
Such an arrangement is followed out in most loose-couplers or receiving transformers of the more modern kind, although some still cling to a sliding contact on the primary and a switch on the secondary. The finer tuning in this and other apparatus is done with variable condensers.

Loading coils are merely large coils used to increase the inductance of the circuit when the inductance of the receiving transformer is not great enough to be tuned to the wave-length received. Ordinary tuning coils and the coils of receiving transformers of the inductively coupled types are usually 6 to 10 inches long and 4 to 6 inches in diameter, with single layer windings, while some of the common loading coils for long waves are 25 inches or more in length.

The variable condenser generally used today is of the rotary plate type, such as that shown in the accompanying illustration. A set of semi-circular plates is rotated between a corresponding set of fixed plates, forming alternate layers of air dielectric with adjacent conductors of opposite polarity.

For most of the foregoing data the authors are indebted to Radio Pamphlet No. 40 of the Signal Corps, U. S. A., which deals with the principles of radio communication as applied to military wireless telegraphy and telephony. In the next section the advanced receiving apparatus and arrangements are covered, particularly the amateur equipment that has come into use since the ending of the great war.

*This series dealing with wireless telegraphy and telephony for the beginner in the art. Began with I in Scientific American Supplement No. 2270, dated July 5, 1919; II in No. 2273, dated July 26, 1919 and III in No. 2275, dated Aug. 9, 1919. Every phase of amateur radio is being covered in this series, in a simple, clear and thorough manner, together with the latest commercial practices. (Copyright, 1919, Scientific American Publishing Co.)



Two-slide tuning coil — Conventional loose-coupler — Improved buzzer — Variable plate condenser

Various pieces of receiving equipment—the buzzer excepted—which are now considered suitable for the beginner in the art

Separating Visible from Invisible Light*

By W. S. Andrews

Below is described an ingenious apparatus which has been constructed by the author to separate visible from invisible light.

Prof. R. W. Wood delivered a lecture before the Royal Institute of Great Britain in 1911 on "Invisible Light," and described a method for separating the invisible ultra-violet rays from visible light of a mixed spectrum.

A simple and inexpensive apparatus based on Prof. Wood's idea has been made and its operation is so satisfactory that description of it may be found acceptable.

Figure 1 illustrates the principles of this apparatus in diagramatic form, the letters referring to the different parts, as explained in the following:

A, Source of visible light mixed with a large percentage of ultra-violet radiation such as may be produced by a high-tension disruptive spark between iron terminals;

B, a quartz lens;

D, a diaphragm of thin sheet metal pierced with a fine pinhole at *C*, the diaphragm being so placed that the pinhole is in the exact mean focus of the ultra-violet rays;

E, An imaginary line indicating in an exaggerated degree the mean focus of visible light from source *A*;

F, a small metal disk the function of which will be described later;

G, a screen of cardboard or other suitable material.

H, a front view of the screen *G*.

The operation of this instrument, which naturally must be in a darkened room, is based on the fact that the mean focus of visible light is located at a measurable distance beyond the mean focus of invisible ultra-violet light owing to the greater refrangibility of the latter over that of the former.

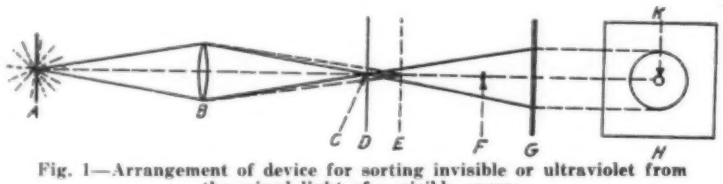


Fig. 1—Arrangement of device for sorting invisible or ultraviolet from the mixed light of a visible source

If, therefore, the diaphragm *D* is carefuly adjusted so as to bring the pinhole *C* into the exact mean focus of ultra-violet light, the rays of the latter will pass through the pinhole and spread out again on the other side of the diaphragm. The mean focus of visible light being some distance *beyond* the pinhole, its rays will be largely intercepted by the diaphragm, through the pinhole in which only a few of the nearly parallel rays of visible light will pass.

In operation, if the screen *H* is made of non-fluorescent material, there will appear on it only the small illuminated spot *K*, but if it is coated with a fluorescent substance, such as powdered willemite, this small luminous spot will be surrounded by a disk of bright green light produced by the fluorescence of the willemite excited by the circular field of invisible ultra-violet rays. Should it be found desirable to cut out the spot of visible light, the small metal disk *F* can be set up in such a position as to cast its shadow over the spot *K* and so transform it from a bright spot to a dark one, leaving the disk of green fluorescent light otherwise unimpaired.

Figure 2 shows the external appearance of this apparatus, which includes the spark gap *A*, the quartz lens *B* and the diaphragm *D*.

The screen *G-H* and small stop *F*, being external movable adjuncts, can be located so as to meet desired conditions of work. The size of the luminous disk that is formed on the fluorescent screen by the conical beam of ultra-violet light is naturally regulated by the distance of this screen from *D*, and the movable stop *F* may be adjusted to a proper position, or not used at all at the option of the observer.

This apparatus is valuable for determining the exact fluorescent colors of various compounds. When such compounds are exposed to the direct rays of an open iron spark, their true fluorescent color is masked to a greater or lesser degree by the visible light component of the spark, this being especially the case with compounds that show only a weak intrinsic fluorescence. When a compound is placed within the invisible field of the ultra-violet rays of this *separator*, it shows its true fluorescent color, and the passing it thus into a visually dark field and its becoming thereby illuminated produces a surprising and interesting effect.

*From *General Electric Review*.

Military Camouflage

Articles on military camouflage have frequently appeared in both scientific and popular journals, but the picture drawn is invariably very different from the reality as seen by those who made the camouflage. The following remarks attempt to correct some of these inaccuracies by setting out as clearly as possible the conditions under which the military camoufleur worked.

Military information is obtained by horizontal observation from first-line trenches, by horizontal and oblique observation from kite-balloons, and by vertical observation from aeroplanes. Horizontal observation has a limited field of a few miles, whereas vertical observation is limited only by the distance an aeroplane can cover and return. The latter is thus of much the greater importance, especially because with the aid of photography very much greater detail can be obtained than by direct observation.

Even in forward areas open to horizontal observation camouflage requires to be proof against aerial photography. What escapes the long-focus camera carrying rapid and fine-grained plates will be passed by the eye even aided by optical instruments.

An example will illustrate most of the governing factors. Suppose that it has been decided to conceal a machine-gun emplacement by an artificial haystack. Either it must take the place of an existing stack or recently cut grass must account for its sudden appearance in the photograph. The comparison of photographs taken at different dates was a routine practice. The artificial stack must be of the size and form of haystacks of the neighborhood; any defect in these respects would be recognized photographically by measurement of its cast shadow or by exaggerated stereoscopic examination. Any two photographs taken from about the same height suffice for stereoscopic examination.

If the stack be made of artificial material, such as canvas, and matched in color to the eye, it may be discovered by the use of color-filters or plates sensitive to special regions of the spectrum. The Germans used a very rapid plate the sensitiveness of which was almost confined to the green region. To ensure that the color composition of the artificial was not at fault, it is best to use hay or straw in its construction. This is best for another reason in order to copy so far as possible the texture of the natural, for under the changing angles of illumination in Nature it is not possible to match constantly a rough surface by a smooth artificial, and this difference is likely to be seen sooner or later by the reader of aerial photographs. It is clear, therefore, that to defeat the aerial camera an exact copy is required. Among animals such concealment is comparable with that of Kallima, the leaf-butterfly. What may be termed impressionistic methods commonly found in animal coloration are quite useless for the defeat of the reader of aerial photographs. For concealment against horizontal observation the same methods had to be employed, as the object is constantly being scrutinized by many eyes, aided by binoculars, color-filters, etc., exercising systematic observation, as well as being subject to vertical observation. An observation post in a sandbag parapet had to be concealed by a wire-gauze screen modelled to resemble exactly the sandbag removed for the purpose.

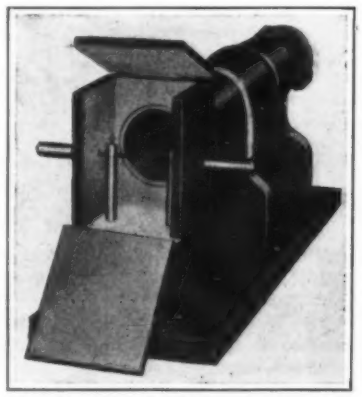


Fig. 2—General view of apparatus showing iron spark-gap light source

Many military objects were successfully concealed by erecting flat covers over them. These were made of fish- or wire-netting threaded with strips of canvas painted green or brown, according as to whether the surroundings were grass or earth. The paints used were made to give as nearly as possible the same color-composition as grass, earth, etc. The required texture was obtained by leaving the ends of the canvas strips long. The cast shadow was concealed by gradually thinning out the canvas strips towards the edge, so that no defined shadow was cast. Under such covers, and more especially on rough ground, guns and other military objects were successfully concealed. This is, again, a case of exact copying except for the cast shadow, which is concealed by thinning out the edge in a manner similar to the standing coats and serrated edges of some animals.

The difficulty of concealings guns was greatly increased because they could be located with considerable accuracy by flash-spotting and sound-ranging, though to pin-prick them on the map detection by aerial photography was required. Still, these other methods of detection narrowed down the area to be examined often to the size of a halfpenny.

Further, the reader of aerial photographs became very skilled in detecting the presence of concealed objects from signs, tracks, moved earth, unusual agricultural activities, activities along roads and rails, so that a camouflaged object was likely to be subject to the minutest examination and the smallest defect unlikely to be overlooked.

Meticulous care in the smallest detail was, therefore, essential, especially because a detected camouflage gave a false security. The degree in which accuracy was necessary may be conveyed by the following example: An attempt was made to represent a light-railway track by dark lines painted upon canvas, the canvas representing ballast. The painted rail was not so dark in the photograph as the real rail. It was found essential to make a raised rail of rope and canvas in order to cast the same shadow as a steel rail.

Unfortunately, especially during the early stages of the war, commanding officers often did their own camouflaging. This work almost invariably consisted of imitative painting, generally of an exceedingly childish kind, or, on the other hand, they succeeded in making the object more conspicuous by the use of conventional patterns in gaudy color. In fact, painting for land camouflage was of no value except possibly to lower the reflection at night from, say, a hospital roof by the use of dark green or black paint which no texture was available. It is from the work carried out without technical advice from the Camouflage Corps that the public has been led astray, and it is to counteract this incorrect impression that the foregoing description may be of value.—Adrian Klein & J. C. Mottram, in *Nature*.

Elementary Theory of Atmospheric Reflections

A. Wegener gives a simple quantitative theory of mirage and similar atmospheric optical phenomena due to reflections at surfaces of density inversion or discontinuity. Numerical results of the theory are given in tabular form.—*Science Abstracts*.

Conditions Inside a Star

Dealing with giant stars of such low density as to behave like a perfect gas, and taking radiation-pressure into consideration, A. S. Eddington finds it possible to simplify his equations on the assumptions that the absorption coefficient does not vary throughout the star, and that the rate of outward flow of energy is proportional to gravitation. With the aid of Emden's solution of a problem involving a similar quadrature, he arrives at the definite conclusion that "the luminosity (or more strictly the total radiation) of a giant star is, for a given mass, inversely proportional to its opacity and is otherwise independent of its density or stage of evolution," or in other words, "for stars of the same mass, the effective temperature is proportional to the sixth root of the density." This explains the small range of absolute luminosity of giant stars of all spectral types, provided that the opacity is the same. Adopting a molecular weight of 2.8, on stated theoretical grounds, the author finds the absolute magnitudes for stars of masses ranging from ½ to 13 times that of the sun, showing for the F and G stars in Adams' and Joy's list the small range of 0.7 to 1.6 times that of the sun. Further inferences are drawn: (1) That this small range of mass is due to the operpowering effect of radiation-pressure; (2) that this effect is due to the stars being exceedingly opaque to radiation, and (3) that this radiation within the stars must be of very short wave-length, like X-rays. The first of the two assumptions referred to above appears to be justified by the results, but the ratio of outflow of energy to gravitation is not quite constant, seeming to increase slowly towards the center. The paper concludes with a table of density and temperature within a typical giant star of mass 1.5 times that of the sun, showing a great condensation of density towards the center.—*Science Abstracts*.

Specific Nutritive Values

(*Continued from page* 123)

While a specific nutritive value of extracts has thus far been proved only in the case of extracts of vegetable origin it appears to be quite possible that similar effects are exerted by extractive matters of a different origin, i. e. those from meat. It may be possible to explain in this manner the nutritive value existing in meat broth or meat extract. It is probable that we must also regard the effects exerted by certain constituents of the ductless glands as of the same nature.

I have thus far considered exclusively the organic elements of our food supply. It scarcely needs to be mentioned that the inorganic elements must also be considered. The nutritive value of the latter must be regarded as residing entirely in what we have termed the "specific nutritive value" . . . for other reasons I cannot here take up this question more in detail, especially as the part played by certain mineral elements of high physiological value in nutrition is still entirely unexplained."[a]

The preceding observations have clearly proved in my opinion that it is henceforth impossible to express the nutritive value of a food in simple figures, since, as we have seen, the nutritive value is constituted by the combination of several entirely incommensurable magnitudes, hence the value of any given means of nutrition must be calculated from various points of view, according to which we shall find the value of meat very different from that of fruit, that of sugar from that of butter, and that of milk from that of potatoes; . . . and it is only this enlarged conception of the idea of "nutritive value" which will enable us to bring the theoretic principles of the science of nutrition into harmony with practical experience. . . .

* * *

To sum the matter up the conclusion is forced upon us that we must no longer regard albumen as the only indispensable element in our diet. . . . We have demonstrated, on the contrary, that the nutritive fats, the carbohydrates, and the extractive matters exert certain specific effects in nutrition which are connected with the characteristic properties of these forms of food and cannot be produced, therefore, by other foodstuffs. These specific effects are in no wise connected with the capacity of the various foodstuffs to liberate heat. . . . This "specific nutritive value" must be differentiated from the caloric value common to all organic foodstuffs. Finally the diet must contain a minimum amount of each of the organic food groups as also of extractive matters and of mineral salts. . . .

[a] H. Aron, The Inorganic Constituents of the Animal Organism (in German), Handbuch f. Biochem. (Handbook of Biochemistry), 1909, 1, p. 62 and following.

Origin of American Agriculture

(*Continued from page* 121)

In the great Amazon Valley, and in the flanking valleys of the Orinoco and the Plata, we find agriculture unaccompanied by high social developments; although weaving and pottery-making are everywhere practised. Maize, beans, and squashes are known throughout this area, but maize is displaced from the position of first importance by manioc. Two species of this plant are used, one having a poisonous juice, the other being harmless. Both plants, along with many other species of the same family, are said to grow wild in Brazil, and there is little doubt that domestication first took place in this area. A single technical process of extracting the poisonous juice of the favorite manioc is found wherever the plant is cultivated, and similar types of clay griddles are used in making the cassava cakes.[b]

The third type of agriculture was adapted to temperate conditions. It is most completely exemplified in the eastern half of the United States, but seems also to have been developed, although to a much less extent, in parts of the Argentine and Uruguayan pampas. Maize is again the staple, with beans and squashes as associated crops. Among the Mandan Indians of North Dakota maize was modified to meet the conditions of a very short summer and to ripen within sixty or seventy days after planting. Among the Iroquois agriculture was also brought to a high plane, especially when we consider that all the plants under cultivation were indigenous to the tropics.

If we glance at the crop report of the United States, we find that the annual value for this country alone of plants brought under cultivation by the Indians amounts to three thousand millions of dollars—and the debt of the world is only partly acknowledged. Maize is our principal farm crop, and in its production we lead the world, but in certain other products of the American Indians, such as beans and potatoes, the production of the United States is but a very small part of the world's production. If we remember that in the four hundred years that the white man has dominated the New World he has not reduced to cultivation from wild stock a single important staple, the wonder of the American Indian agriculture becomes still greater.

[b] If we should extend our study of agriculture to semi-cultivated trees, the list of valuable products would be greatly increased. Mention may be made of the favorite alligator pear, whose current name is a gross mispronunciation of *aguacate*, of several members of the anona or custard-apple family, including the soursop or guanabena, the chirimoya or sweetsop, and the custard apple, of the granadilla which is the fruit of the passion flower, of the lucuma and its relative the marmalade plum, of the star apple, of the sapote or nispero, of the mamey apple, of the nance or Barbados cherry, of the guava, of the ciruela or jocote, and even with these names the list is far from complete.

Nor can we take time to more than mention some of the other important economic plants cultivated by the Indians. Of these the first in value is the modern cotton of commerce. The cultivated cotton of the American Indians has virtually displaced the Old-World types. Many other fiber plants were also brought under cultivation such as henequen. Tobacco was widely domesticated from several species both in temperate and tropical America. Important medicines derived from the Indians are cascara sagrada, cocaine, and quinine.

Hull Form for High Speeds

THE author studies the variation, with velocity V, of resistance R offered to the movement of hulls through the water, and evolves a criterion which makes possible the determination of profiles (in planes parallel to the water line) yielding minimum resistance. By the aid of a coefficient characteristic of its lateral convexity, it is possible to determine immediately the suitability of any hull for high speeds. The formulæ given are based on experiments conducted in the open with a great variety of types of vessel. Two categories of vessel must be distinguished, namely, those which maintain a horizontal position at all speeds, and those which change their plane of flotation beyond a critical speed W, for reasons and under conditions set forth in the paper. Vessels fall in the first or second category according as the coefficien w of lateral convexity of the hull is greater or less than 0.18; where $w = (\sin I . \sin Im)$, Im being the mean of the max. angles of approach I, I′ etc. of the water lines of the stem parallel to the plane of floating, among which I is that of the water line of this plane. Mathematical justification is given for the main features of design of racing boats, *i. e.* short length and flat bottom below the poop. The formulæ evolved are applied to a 35-knot topedo-boat destroyer. In order to determine whether any form of hull is capable of assuming an inclination favorable to high speed, by submersion at the stern and corresponding rise at the stem, it is only necessary to determine whether w is less than 0.18, with a lower limit 0.09.—E. FOURNIER, in *Comptes Rendus*.

Illuminating Devices in the Great War

(*Continued from page* 115)

lumination obtained is in almost direct opposition. It is possible to obtain almost any time of burning desired but the longer this time is the lower will be the luminosity. Chemists and designers usually pick a mean. Illumination of more than two minutes is seldom desired or desirable.

The description given above of the functioning of a shell in the air probably sounds simple but there is really much more to the problem than indicated. In the first place the shell is traveling at a very high rate of speed when the contents are ejected to the rear. This speed will vary with the gun or howitzer used and also with the range at which the time fuse is set to burst the shell. It may be as high as 1,500 feet per second but is more usually around 1,000 feet per second. This may not be as vivid to the average reader as it would be to state that the shell was traveling at the speed of 11 miles per minute which is about equivalent to 1,000 feet per second. At this high speed the powder gases unceremoniously eject the shell's contents. To be sure the ejection is to the rear and therefore in the opposite direction to the motion of the shell but the rearward velocity is nowhere near as great as the forward velocity. It would be impossible to put charge enough in the nose to do this. The resultant velocity of the container and contents is, then, still forward and equal to the difference between the velocity of the shell at that instant and the backward velocity of the contents due to the head charge. The shell really acts as a small gun. When the contents are once free from the shell they may be considered as a free body. The mass of the container filled with the illuminant is considerable. The air catches the parachute and snaps it open thus tending to check the forward velocity. A very large area is suddenly exposed to the air. The parachute cannot stop the mass quickly without applying a very high force. This is just what it trys to do with results that are often disastrous to the parachute. It is difficult if not impossible to calculate these forces mathematically, due to the lack of data. We can do but little better than build our parachute as strong as possible and trust more or less to luck that it does not go to pieces. This trouble is increased with steel containers and for this reason some designers have used the lighter cardboard. These meet with difficulty, however, in the gun, where the heavy set back is apt to crush them to pieces. The mixture in the container must be compressed initially more than the set back force otherwise it will compress in the gun often with sufficient friction to fire the mixture and give a premature explosion. Such high pressures are not always possible to use with paper containers.

Parachutes are sometimes made from a good grade of silk but usually this material is not sufficiently strong for the larger calibers. Heavy duck or better yet a good grade of airplane linen serves the purpose very well. This linen is the same as used on the wings of airplanes and is very strong in proportion to its weight. It may be doubled if greater strength is desired. The parachute is usually attached to the container by means of small hemp or wire ropes. The former are the better if they can be secured of sufficient strength. Steel rope is apt to cut into the fabric and also into itself under the compression stresses in the gun.

Great difficulty has been encountered in the perfection of the device described above. Much experimental work still remains to be done before we can say we have a satisfactory illuminating shell of this type. It is a problem which requires years of painstaking effort on the part of well-trained ordnance engineers. Time of peace is then the time when such work should be carried out and not during the excitement of war. Money should not be lacking for the carrying out of such necessary experimental and development work.

Many variations from the shell described above are to be found. Some designers for example eject their contents to the front instead of to the rear. This on the face of it would seem to be bad practice as by so doing the two velocities, namely that of the shell and that given the contents by the head charge, are added instead of subtracted as in the case cited before. If we are looking for ways and means of reducing our parachute stresses this is most certainly one of the ways *not* to do it. This scheme has another drawback. When the contents are ejected to the rear the shell is ahead out of the way. When the contents go forward the shell is almost certain to crash into the parachute and container because the latter quickly slow up when the parachute opens. This may so entangle the mass that it comes down a wreck or is carried on with the shell. This is a real difficulty and is present in the case of the steel base plug shown in Fig. 1. The plug has a high sectional density and continues forward at high speed. Unless the parachute is deflected out of the path of the base plug before it opens the two are apt to come together and it is not unknown to have failure due entirely to the collision in the air, the plug bringing the parachute and container down with it in a tangled wreck. To overcome this trouble which was early recognized the base plug is either offset from center or weighted on one side. The rotation will then tend to throw this plug to one side as soon as it is free from the body of the shell. It is not possible to cause much deflection in this way but usually enough to remove the trouble.

Some designs place a charge of powder in the base and arrange the construction in such a way that the explosion of this powder at the proper time will tear off the rear of the shell exposing the parachute. The air then catches the exposed part and pulls the parachute and attached container out of the shell. Such designs have never been entirely successful. Similar arrangements have been applied to the nose of the shell but with no more success. Such designs are usually complicated. An illuminating shell known as the foliating shell was brought out during the war and at first great results were claimed for this new invention. The design was very complicated and it is doubtful if real good results can ever be obtained. One of the fundamental principles in the development of these shell as with anything else mechanical is simplicity. The more simple the design the more certain it will be to function. Don't try to accomplish too much with one shell. If you do the efficiency and certainty of the whole is apt to be materially reduced.

(*To be continued*)

Effect of Fog on Light Intensity

(*Continued from page 124*)

The results of the tests just quoted may be stated to be in substantial agreement with the results of the tests reported by Mr. Utterback.

Mr. M. Luckiesh of the Nela Research Laboratory in a paper on "Yellow Light," read before the Illuminating Engineering Society at Washington, D. C., in September, 1915, reports a test which is of significance in that its results do not disagree with those of Mr. Utterback. Experiments were made with automobile headlights on a foggy night. One headlight was provided with a greenish yellow glass, the other with a white glass. Four observers agreed that distant objects in the fog were better seen by the greenish-yellow light, although the luminosity of the greenish-yellow beam was 25 per cent lower than that of the white beam.

The effect of a fog in transmitting a smaller percentage of red light and a larger percentage of yellow and green light than of any other color as reported by Mr. Utterback and other experimenters may perhaps be attributed to the selective action of water upon these colors. As is well known a fog consists of small drops of water suspended in the air. In passing through a fog part of the light at least must pass through the water drops. Water absorbs red light strongly and transmits yellow and especially green much better. Red objects when lowered into water lose color and turn black. White objects acquire a greenish color when immersed in water. If an empty tube closed at the bottom with glass be lowered into the water and the white object be viewed through the tube when close to its lower end, its green color is still observed. This shows that the light which penetrates the water is greenish by absorption. In the *Journal of the Franklin Institute*, March, 1919, Professor Bancroft of Cornell University gives an interesting review of experiments which prove that water absorbs red and transmits green.[1]

In considering the bearing of the results reported in this paper upon practice it must be remembered that of the factors which tend to reduce the transparency of the atmosphere only one is here investigated, namely, fog, suspended water drops. Small solid particles suspended in the air undoubtedly seriously affect its transparency and in a way differently from fog. The deep red color of the sun observed through smoke or haze indicates that an atmosphere laden with solid particles is best penetrated by red light. The complete study of transmission of light through the atmosphere must involve studies of each of the factors which affect its transparency.

Enoch Karrer and E. P. T. Tyndall: The subject of the transmission of light through fog is an important one in headlight illumination, in military searchlight illumination, and in aerial photography.

The work now under way at the Bureau of Standards on the transmission of light through the atmosphere was undertaken in connection with the tests of military searchlamps.

The subject has a two-fold importance in connection with military searchlamps, *viz.*: (1) in the standardizing and comparing of searchlamps; (2) in the actual use of searchlamps.

In the former case it is necessary to make measurements of the intensity of illumination upon targets at great distances from the searchlamp. It is desirable to know what effect the atmosphere traversed by the beam may have upon the data obtained at different hours of the night and on different nights.

In the second case, a knowledge of the effect of the atmosphere upon a searchlight beam is important from two standpoints:

1. The intensity of illumination at the target and at the eye of the observer is dependent in part upon the transparency of the atmosphere.

2. The seeing of the target is conditioned by the brightness of the path of the beam, through which and along which the observer must look in order to see an object illuminated by the searchlamp.

The path of the beam is made apparent by the diffusion of light by the atmosphere.

It is of interest to divide the mechanisms by which the light is diffused into three, *viz*:

1. Diffusion by the molecules of gases in the atmosphere.

2. Diffusion by the particles of water and water vapor.

3. Diffusion by the solid particles suspended in the atmosphere.

Examples of the first are, the blue sky and the path of the searchlight beam on clear nights and at high altitudes. Examples of the second may be seen during rainy, foggy and misty weather. Examples of the third are seen in hazy and smoky atmosphere.

The kind of diffusion in the three cases may be different. Diffusion by the molecules and very small insulating particles varies inversely as the fourth power of the wave-length of the light. When the particles become comparable in size to the wave-length of light and larger, this law no longer holds. The exact nature of the diffusion will depend somewhat upon the optical and electrical properties of the material of the particles and upon their shape. This fact is brought out in the differently colored smokes for military and other purposes.

A close study of the diffusion of light by foggy atmospheres has not been made, particularly not during natural fogs.

There is then a point of uncertainty in connection with Mr. Utterback's fogs, as to whether they may be called typical of an outdoor natural fog.

There must have been considerable scattering of the beam by the fog in the tube to account for the low transmission, for, most probably, there was not present a sufficient quantity of water to absorb the light to this extent. It would be interesting to have had on record the amount of water that was actually suspended within the tube. This scattered light should have been detected at the windows (*F* in Fig. 1).

In certain cases the illumination was very low where errors of observation are high. The method of isolating regions of the spectrum by glass screens leaves much to be desired for phenomena of this kind.

There must have been present very pronounced color differences when the fog was present and when no fog was present.

Some preliminary data obtained at the Bureau do not indicate the existence of such pronounced selectivity. Rather there is a definite rise of transmission toward the red even though minor elevations and depressions may be present. This is in accord with general observations by lighthouse engineers.

More work must be done, however, to establish this.

In conclusion it may be said that so far as the detrimental effects of diffusion of light are concerned, blue light is the least desirable kind of light to have in searchlight beams and in headlight beams. The fact that the eye cannot accommodate so well for short wave-lengths is a concurrent cause for pronouncing blue undesirable.

It may be pointed out, however, that for military purposes, blue may be desirable and necessary in detection of camouflaged targets.

C. L. Utterback (in reply to T. D. Cope): The results of the tests performed by Mr. M. Luckiesh have no bearing on the results given in this paper. Mr. Luckiesh determined relative visibility, while the writer measured the intensity of colored light after it had passed through a definite length of fog.

In regard to dust particles in the air; it is, in general, when they are present that fogs are formed in nature. It was only under these conditions that measurements were made.

C. L. Utterback (in reply to Messrs. Karrar and Tyndall): The fogs studied were produced in air which was filled with dust particles and it is believed that such a fog is fairly typical of outdoor fogs, at least in cities.

In quoting from the results obtained by the U. S. Bureau of Standards no information is given as to the character of the fogs used and, if the contention of Mr. Karrar is correct that the kind of dust particles is an important factor, then his comparison of the selectivity of the two fogs has no point.

The scattering of the beam by the fog in the tube was not considerable as was shown by the failure to obtain readings at the windows, *F*.

The pronounced color difference on the plate *E* were only differences in shade and this difficulty as well as the low illumination was partly overcome by taking a large number of readings for each condition, and by having three different persons take readings.

It is hoped that in the near future a report can be made on the effect of different dust particles in a fog, and also the effect produced by outdoor fogs. The amount of water in the fogs will also be noted.

[1] See SCIENTIFIC AMERICAN SUPPLEMENT, Nos. 2267, 2268, 2269, 2273.

The Ultra-Violet and Visible Transmission of Eye-Protective Glasses

MANY glasses are on the market and extensively advertised to protect the eyes from injurious radiant energy. Unfortunately, but little authoritative information concerning the properties of these glasses has been available. The public and even oculists and physicians have had little to guide them in selecting such glasses except the claims of makers and agents. One purpose of such glasses is to absorb the injurious radiant energy which is emitted with the light from certain lamps as well as from welding arcs and industrial furnaces, while transmitting sufficient light for vision. They thus act as filters. Another purpose in certain cases may be to absorb part of the light so as to reduce a blinding brilliance. Glasses of different types are required for different needs. The degree to which these glases actually fulfill their avowed purpose can only be determined by measurements of their "transmission" (i. e., the ratio of transmitted energy to the energy falling on them) for the various forms of radiant energy in question. The Bureau of Standards has made such measurements on a great number of glasses now on the American market and the results are published in this paper. (Abstract from U. S. Bureau of Standards, Technologic Paper No. 119.)—*Mech. Engineering.*

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